Exhibit 10

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,

Petitioner

v.

COREPHOTONICS LTD.,

Patent Owner

IPR2020-00905
U.S. Patent No. 10,225,479

PETITION FOR *INTER PARTES* REVIEW
UNDER 35 U.S.C. § 312 AND 37 C.F.R. § 42.104

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May 6, 2020

APPL-1001	U.S. Patent No. 10,225,479 to Shabtay et al. (the "'479 Patent")
APPL-1002	Prosecution File History of the '479 Patent (the "'242 App")
APPL-1003	Declaration of Dr. Fredo Durand Ph.D.
APPL-1004	CV of Dr. Fredo Durand
APPL-1005	U.S. Patent No. 7,859,588 to Parulski et al. ("Parulski")
APPL-1006	Used in co-filed Petition
APPL-1007	Used in co-filed Petition
APPL-1008	Used in co-filed Petition
APPL-1009	Used in co-filed Petition
APPL-1010	Used in co-filed Petition
APPL-1011	Used in co-filed Petition
APPL-1012	Used in co-filed Petition
APPL-1013	Richard Szeliski, COMPUTER VISION – ALGORITHMS AND APPLICATIONS (2011) ("Szeliski")
APPL-1014	Used in co-filed Petition
APPL-1015	JP Pub. No. 2013-106289 to Konno et al. ("Konno"), Certified English translation and Original
APPL-1016	Used in co-filed Petition
APPL-1017	Used in co-filed Petition
APPL-1018	U.S. Patent No. 7,206,136 to Labaziewicz et al. ("Labaziewicz")
APPL-1019	Used in co-filed Petition

APPL-1020	Warren J. Smith, MODERN LENS DESIGN (1992) ("Smith")
APPL-1021	Declaration of Dr. Jose Sasián, Ph.D.
APPL-1022	ZEMAX Development Corporation, ZEMAX Optical Design Program User's Manual, February 14, 2011 ("ZEMAX User's Manual")
APPL-1023	U.S. Patent No. 8,908,041 to Stein et al. ("Stein")
APPL-1024	U.S. Patent No. 8,406,569 to Segall et al. ("Segall")
APPL-1025	U.S. Patent No. 8,824,833 to Dagher et al. ("Dagher")
APPL-1026	Used in co-filed Petition
APPL-1027	File History for Provisional No. 61/752,515 to Stein ("Stein provisional")
APPL-1028	Used in co-filed Petition
APPL-1029	Used in co-filed Petition
APPL-1030	Used in co-filed Petition
APPL-1031	Product announcement for Sony ICX612 12 MP image sensor
APPL-1032	Product announcement for Sony ICX652 13.5 MP image sensor
APPL-1033	Used in co-filed Petition
APPL-1034	U.S. Patent No. 7,112,774 to Baer
APPL-1035	Robert E. Fischer et al., OPTICAL SYSTEM DESIGN (2008)
APPL-1036	Email from Patent Owner's counsel authorizing electronic service

I. INTRODUCTION

U.S. Patent No. 10,225,479 (the "'479 Patent," APPL-1001) is generally directed to a "dual aperture" digital camera. *See* APPL-1001, Title. The claims challenged in this Petition recite two types of limitations— (1) a camera with wide and telephoto lenses having overlapping fields of view (FOVs) and (2) a camera controller that outputs an image with a broader depth of field by fusing only in-focus portions of the telephoto image with the wide image.

This Petition, along with the cited evidence, demonstrates that claims 1-16, 18, 23-38, and 40 are obvious under 35 U.S.C. § 103. Petitioner Apple Inc. requests that these claims be held unpatentable and cancelled.

II. MANDATORY NOTICES

A. Real Party-in-Interest

The real party-in-interest is Apple Inc.

B. Related Matters

As of the filing date of this Petition and to the best knowledge of Petitioner, the '479 Patent has been asserted in the following matters:

- *Corephotonics Ltd. v. Apple Inc.*, Case No. 5-19-cv-04809 (N.D. Cal. filed August 14, 2019).
- Petitioner is concurrently filing IPR2020-00906 directed to claims 19-22.

C. Lead and Back-up Counsel and Service Information

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Please address all correspondence to lead and back-up counsel. Petitioner consents to electronic service.

III. GROUNDS FOR STANDING

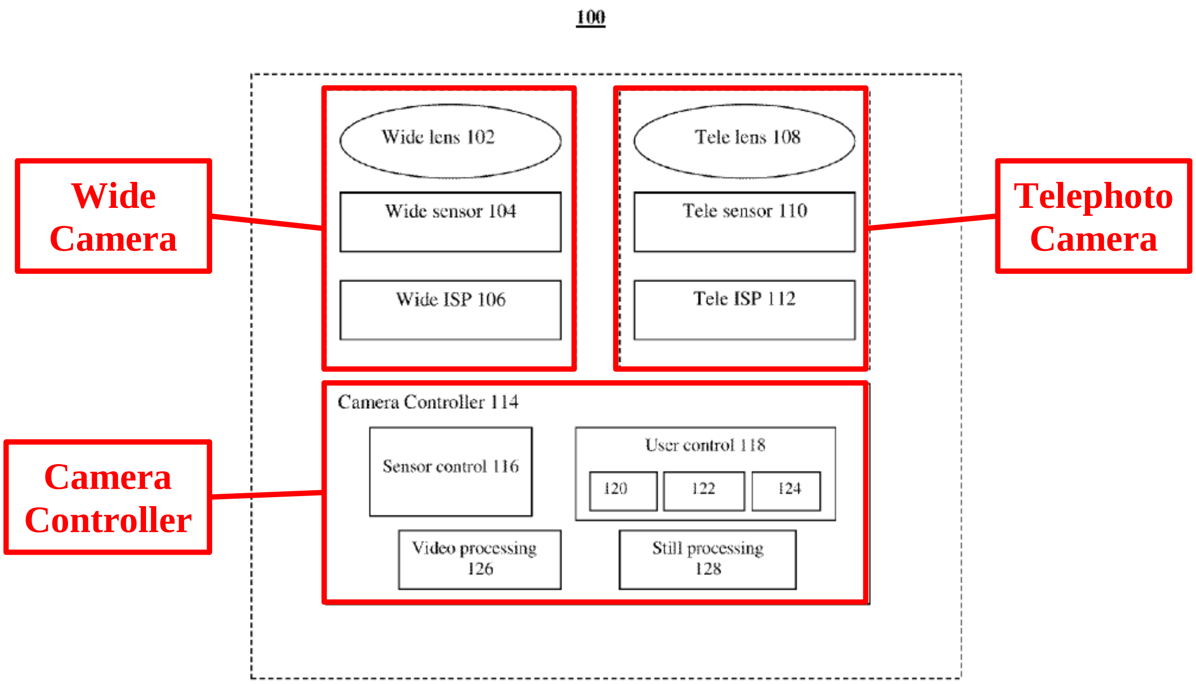
Pursuant to 37 C.F.R. §42.104(a), Petitioner certifies that the ’479 Patent is available for *inter partes* review and that Petitioner is not barred or estopped from requesting an *inter partes* review challenging the claims on the grounds identified in this Petition.

IV. THE ’479 PATENT

A. Summary of the Patent

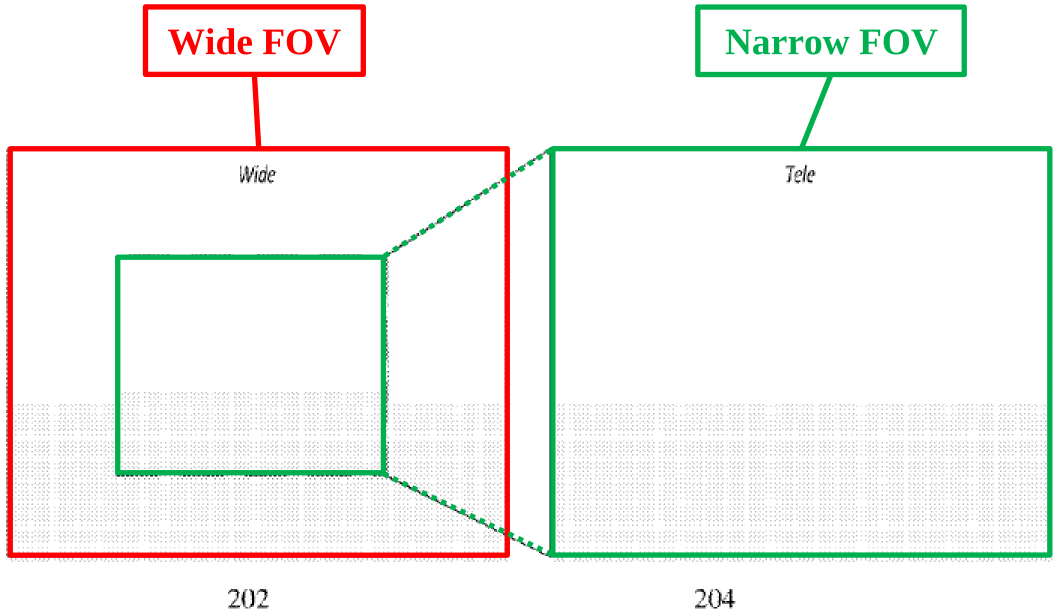
The ’479 Patent describes a “dual-aperture zoom digital camera operable in both still and video modes.” APPL-1001, Abstract. Figure 1A diagrams the

patent's camera as a dual-aperture Zoom imaging system 100 including a first Wide imaging section and a second Telephoto imaging section, with each section having respective lenses and image sensors:



APPL-1001, Fig. 1A (annotated).

Figure 2 of the '479 Patent illustrates the respective fields of view (FOVs) of the Wide and Telephoto image sensors:



APPL-1001, Fig. 2 (annotated). The larger FOV for the Wide image is provided by Wide sensor 202 and the corresponding smaller FOV for the Telephoto image is provided by Telephoto sensor 204. *See id.*, 6:1-2.

With Wide and Telephoto images captured from the respective cameras, the '479 Patent describes several processing methods that can be achieved. In the method that forms the subject of the challenged claims, the image processing first rectifies the Wide and Telephoto images to be aligned on an epipolar line. *See id.*, 9:46-47. Next, the process performs "mapping between the Wide and the Telephoto aligned images" to "produce a registration map." *Id.*, 9:48-49. The Telephoto image is then "resampled according to the registration map" or in other words, resized to correspond to the field of view ("FOV") of the Wide image. *See id.*, 9:50-60. The process finally then fuses or combines portions of the resampled

Telephoto image with corresponding portions of the Wide image to produce an output image. *See id.*, 9:52-67. As part of this fusion step, any errors between the images are detected and if an error exists, "Wide pixel values are chosen to be used in the output image." *Id.*, 9:54-60.

As set forth in this Petition and the accompanying evidence, a dual-aperture camera system having 1) Wide and Telephoto lens systems with overlapping fields of view, and 2) a camera controller that processes images from both systems to outputs an image were known to POSITAs prior to the '479 Patent. *See* APPL-1003, ¶25.

B. Prosecution History and Priority Date

U.S. Patent Application No. 16/048,242 ("the '242 App") that issued as the '479 Patent was filed on July 28, 2018 and claims priority through a chain of applications to a provisional filed on June 13, 2013. APPL-1001, 1:5-20. The '242 application was filed with 40 claims that ultimately issued as claims 1-40 in the '479 Patent. *See* APPL-1002, p.334-66. The '479 Patent issued on March 5, 2019. In the Notice of Allowance, the Examiner's reasoning simply copied the limitations that were found to be patentable including "the Telephoto lens has a respective effective focal length EFL_T and total track length TTL_T fulfilling the condition $EFL_T / TTL_T > 1$. This limitation was known in the prior art.

V. LEVEL OF ORDINARY SKILL IN THE ART

The level of ordinary skill in the art may be reflected by the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). Here, a Person of Ordinary Skill in the Art ("POSITA") at the time of the claimed invention would have a bachelor's or the equivalent degree in electrical and/or computer engineering or a related field and 2-3 years of experience in imaging systems including image processing and lens design. APPL-1003, ¶13. Furthermore, a person with less formal education but more experience, or more formal education but less experience, could have also met the relevant standard for a POSITA. *Id.* However, Petitioner does not imply that a person having an extraordinary level of skill should be regarded as a POSITA.

VI. CLAIM CONSTRUCTION

The challenged claims of the '479 Patent are construed herein "using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b)." 37 C.F.R. § 42.100(b) (Nov. 13, 2018). The claim terms construed below are thus construed "in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent." *Id.* For terms not addressed below, Petitioner submits that no specific construction is necessary for this proceeding.

A. "fused image with a point of view (POV) of the Wide camera" (claims 1 and 23).

This term is used in claims 1 and 23 which both recite: "to output the *fused image with a point of view (POV) of the Wide camera* by mapping Telephoto image pixels to matching pixels within the Wide image."

The Summary section of the '479 Patent describes the concept of POV in regard to the Wide and Telephoto cameras in this way: "In a dual-aperture camera image plane, as seen by each sub-camera (and respective image sensor), a given object will be shifted and have different perspective (shape). This is referred to as point-of-view (POV)." APPL-1001, 5:10-12. Because Wide and Telephoto cameras have different perspectives, the '479 Patent indicates that a fused image (i.e., output image) "can have the shape and position of either sub-camera image or the shape or position of a combination thereof." *Id.*, 5:12-15. "If the output image retains the Wide image shape then it has the Wide perspective POV. If it retains the Wide camera position, then it has the Wide position POV." *Id.*, 5:15-19. The same applies to the images from the Telephoto camera. *Id.*, 5:19-20.

In other words, according to the specification, "*a point of view of the Wide camera*" in the claims can mean one of two things—either "Wide perspective POV" (i.e., wide camera FOV) or "Wide position POV" (i.e., wide camera position). APPL-1003, ¶ 31. When discussing the fusion step, the '479 Patent does not specifically indicate whether position or perspective POV is maintained: "it is

possible to register Telephoto image pixels to a matching pixel set within the Wide image pixels, in which case the output image will retain the Wide POV ("Wide fusion")." *Id.*, 5:23-26. Because the specification describes Wide POV in two ways and does not specify which type is maintained by image fusion, a POSITA would have understood that a fused image that maintains a Wide POV either fuses images to maintain just the Wide field of view or fuses images to maintain both the Wide camera's position. APPL-1003, ¶31.

Based on this description from the '479 Patent, a POSITA therefore would have understood a "fused image with a point of view (POV) of the Wide camera" to mean "*a fused image that maintains the Wide camera's field of view or the Wide camera's position*." APPL-1003, ¶¶32-33.

VII. REQUESTED RELIEF

Petitioner requests that the Board institute *inter partes* review of claims 1-16, 18, 23-38, and 40 of the '479 Patent and cancel each of those claims as unpatentable.

VIII. OVERVIEW OF CHALLENGES

A. Challenged Claims

Claims 1-16, 18, 23-38, and 40 of the '479 Patent are challenged.

B. Statutory Grounds for Challenges

Ground	Claims	Basis
1	1, 10-14, 16, 18, 23, 32-36, 38, 40	Obvious under § 103 over the combination of Parulski and Konno
2	2-4, 24-26	Obvious under § 103 over the combination of Parulski, Konno, and Szeliski
3	5-9, 27-31	Obvious under § 103 over the combination of Parulski, Konno, Szeliski, and Segall
4	15, 37	Obvious under § 103 over the combination Parulski, Konno, and Stein

Parulski (APPL-1005) issued on December 28, 2010, Konno (APPL-1015) published on May 30, 2013, Szeliski (APPL-1013) published in 2011, and Segall (APPL-1024) issued on March 26, 2013. Consequently, Parulski, Konno, Szeliski, and Segall are prior art to under at least 35 U.S.C. § 102(a)(1).

Stein issued on December 9, 2014 from an application filed on January 15, 2014. Stein claims priority to two provisional applications filed on January 15, 2013 and February 7, 2013. Since the provisional application filed on February 7, 2013 support both one claim of Stein and the subject matter relied on in this Petition, Stein is prior art to under at least 35 U.S.C. § 102(a)(2).

C. Page Citations and Emphasis

For exhibits that include suitable page, column, or paragraph numbers in their original publication, Petitioner’s citations are to those original numbers and

not to the page numbers added for compliance with 37 CFR 42.63(d)(2)(ii). The Petition may bold or italicize quotations and add color or colored annotations to figures from exhibits for emphasis.

IX. IDENTIFICATION OF HOW THE CLAIMS ARE UNPATENTABLE

A. Ground 1: Claims 1, 10-14, 16, 18, 23, 32-26, 38, and 40 are obvious under § 103 over Parulski and Konno.

1. Summary of Parulski

Parulski is titled "Method and Apparatus for Operating a Dual Lens Camera to Augment an Image," and discloses "a digital camera that uses multiple lenses and image sensors to provide an improved imaging capability." APPL-1005, Title, 1:8-10. In Parulski, "digital zooming between the wide angle and the telephoto focal lengths" is used to provide an extended zoom range. APPL-1005, 23:54-58; APPL-1003, ¶34. Parulski teaches that its dual lens image capture assembly may operate in still and video modes to produce "still images and motion video images." APPL-1003, ¶35; APPL-1005, 12:36-41. The images can then be "processed by the image processor 50 to produce a processed digital image file, which may contain a still digital image or a video image." APPL-1001, 14:5-9.

More specifically, Parulski describes a cell phone camera with a dual image capture system that "utilize both images to provide an improved output image." APPL-1005, 7:21-24; APPL-1003, ¶36. The output image is generated via an augmentation process that "utilizes one of the images from a dual-lens camera as a

secondary image that can be used to modify the other, primary image and thereby generate an enhanced primary image." APPL-1005, 7:32-35. Parulski describes that its image augmentation process may be applied to "a still image or a video image." APPL-1005, 29:8-20. As shown relative to annotated FIG. 16B below, Parulski goes on to describe its technique using images from fixed focal length wide-angle and telephoto lenses and image sensors. APPL-1005, 23:28-43; APPL-1003, ¶36.

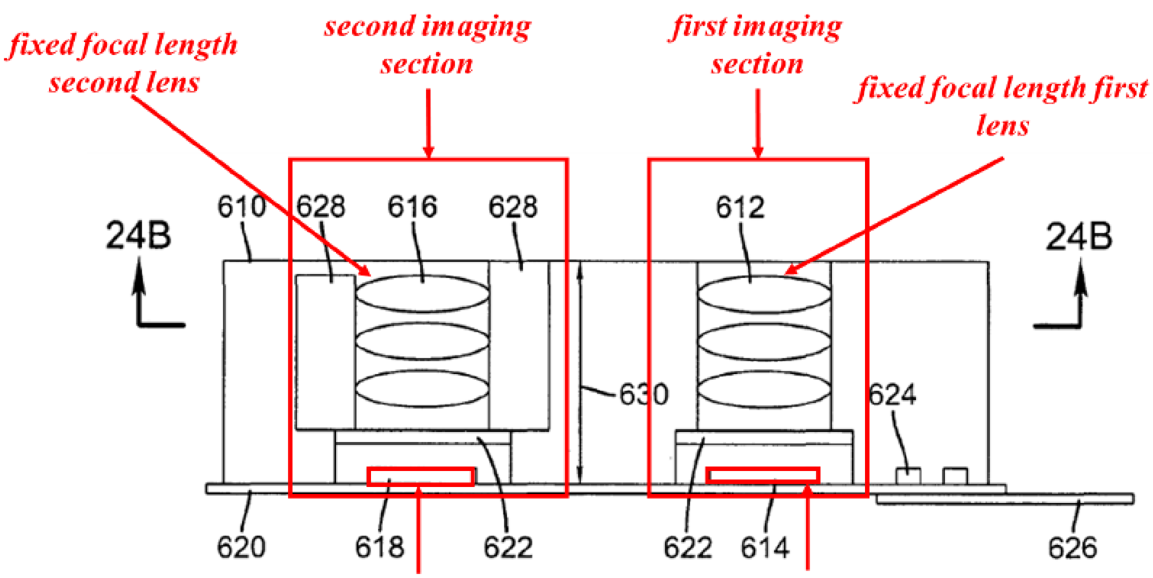


FIG. 16B

APPL-1005, Fig. 16B (annotated).

Parulski teaches using its image capture assembly in a method to enhance the depth of field in Figure 14, which shows "a method for enhancing the depth of field of an image by using images from both image capture stages … " APPL-1003, ¶37; *id.*, 22:14-16; 23:4-7 (explaining that "the integrated image capture assembly [previously described], may be adapted for use in a cell phone." This process is also discussed in

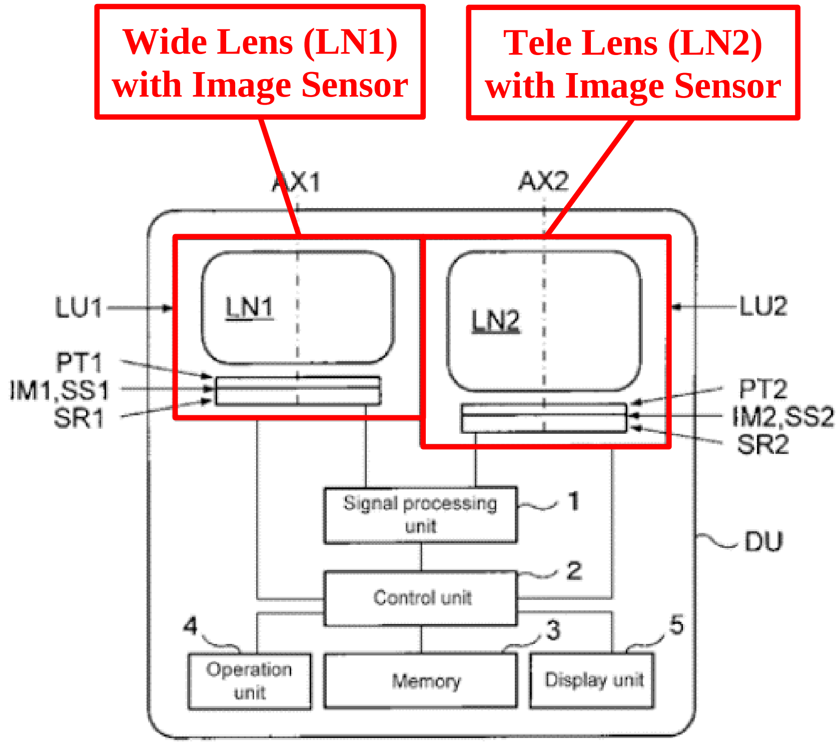
relation to Figure 26 where the primary image is sharpened by fusing focused portions of the secondary image with corresponding portions of the primary image to broaden the primary image's depth of field. *Id.*, 28:47-51 ("Then, the two images are combined into a modified image with a broadened depth of field.").

In sum, Parulski teaches a cell phone camera with dual-lens systems for capturing primary and secondary images with overlapping fields of view (FOVs) and then processing the images to enhance the Wide image by fusing it with focused portions of the Tele image. APPL-1003, ¶46.

2. Summary of Konno

a) Konno's disclosure

Similar to the dual-lens system described in the '479 Patent, Konno also discloses a dual-lens system for use in digital equipment including cell phones. *See* APPL-1015, Abstract, ¶¶ 12, 25 ("digital equipment such as digital cameras, mobile phones, and personal digital assistants."). Konno's dual-lens system is designed to "realize a high-performance slim and small-sized imaging apparatus." APPL-1015, ¶25. One dual-lens embodiment in Konno is Example 2 which has a wide-angle lens LN1 and a telephoto lens LN2 with an EFL / TTL > 1.0. APPL-1015, ¶¶ 7, 14, 40, Table 1. An example of Konno's dual-lens system is provided below:



Ex.1015, Fig. 21.

In the example above, the wide (LN1) and telephoto (LN2) lens systems have fixed-focal-length lens assemblies that project images on to respective image sensors. *See id.*, ¶¶49, 52-53. Each lens system also includes a focus drive element to provide focusing across a range of options. *See id.*, ¶50 ("the first and second imaging optical systems LN1 and LN2 have different focus movements in the case of whole feeding"). Konno's dual-lens system is therefore configured to achieve stereoscopic vision that uses parallax (i.e., spacing between the two sensors) to provide "three-dimensional vision [that] can be displayed at the focal length fm of the second imaging optical system LN2." *Id.*, ¶52; *see also* APPL-1003, ¶47.

Optical data for Example 2 is provided in Table 1 below:

[Table 1]

		Example 1		Example 2	
		LN1	LN2	LN1	LN2
Focal Length of Entire System (mm)	fw or fm	2.73	4.32	3.70	5.51
Fno	FNOw or FNOm	4.00	4.00	3.00	4.00
Lens Entire Length (at infinite) (mm)	TLw or TLm	3.04	3.65	4.45	4.91
Maximum Image Height (mm)	2Y'	5.12	5.12	5.80	5.80
Entire Viewing Angle (deg)	2ωw or 2ωm	86.32	61.28	76.18	55.52
L1 Focal Length (mm)	f1w or f1m	2.60	2.10	2.47	2.54
L2 Focal Length (mm)	f2w or f2m	-7.91	-5.51	-3.53	-4.02
L3 Focal Length (mm)	f3w or f3m	3.14	-13.70	13.47	22.96
L4 Focal Length (mm)	f4w or f4m	-1.68	-3.09	2.42	-5.99
L5 Focal Length (mm)	F5w or f5m	--	--	-1.84	-7.73
Composite Focal lengths of L1 and L2 (mm)	fFw or fFm	3.48	2.91	5.48	4.84
Focal Length of Lens LX (mm)	fXw or fXm	3.14	-13.70	2.42	-5.99
Number of Pixels of Sensor (MegaPixels)	PX	10.00	10.00	13.00	13.00
Segmented Minimum Number of Pixels (MegaPixels)		4.00	4.00	5.86	5.86
Segmented Maximum Focal Length (mm)		4.32	6.83	5.51	8.21
Electronic Zoom Ratio (Power)	ZR		2.50		2.22
Focal Length (135 Conversion) (mm)		23.07	36.52	27.60	41.10

APPL-1015, Table 1.

As shown in Table 1, the "Focal Length of [the] Entire System (mm)" (*f* or EFL), the "Lens Entire Length (at infinite) (mm)" (TTL), "Entire Viewing Angle" (i.e., field of view or FOV), F number, and 35 mm equivalent focal length is provided for each lens system in Example 2. Specific to Example 2, the field of view of LN1 is wider than LN2, LN1 and LN2 have different F numbers, and the EFL/TTL ratio for LN2 of 5.51/4.91 is greater than one thus making LN2 a telephoto type lens. *See* APPL-1020, p.57; APPL-1003, ¶49.

b) Correcting Konno's LN2 lens in the Example 2 embodiment

According to Dr. Sasián (APPL-1021), the LN2 lens in Konno's Example 2 has a small overlap between the fourth and fifth lens elements, which would be recognized by a POSITA upon modelling the LN2 lens. *See* APPL-1021, ¶29. A POSITA would have been able to easily correct this overlap by simply adjusting the fifth lens. *Id.*, ¶30. In fact, by adjusting the fifth lens element position by 0.5 microns (to abut the image-side surface of the fourth lens element), a POSITA would have recognized that the overlap could be resolved and still produce a lens with comparable performance using Konno's data. *Id.*

A POSITA would have understood that performing such an adjustment of the fifth lens by 0.5 microns would have been the natural result of manufacturing the fourth and fifth elements as indicated in Konno and placing the fifth lens as close to the fourth lens as possible. This would have been understood by a POSITA to be the natural result of assembling Konno's Example 2 since two lens elements cannot physically overlap. *Id.*, ¶34. Thus, a POSITA would not have been discouraged to manufacture and use Konno's dual-lens system in cell phone camera since the lens overlap could have been readily resolved in a logical way by simply putting the lens assembly together to the extent possible minus the overlapping elements. *Id.*

3. Reasons to Combine Parulski and Konno

A POSITA would have combined Konno's dual-lens system with Parulski's cell phone camera embodiment because such a combination would have merely been incorporating Konno dual-lens system (with single-focus wide and telephoto lenses) into Parulski's cell phone 600 to obtain the same predictable result of a fixed-focal length, dual-lens camera capable of producing stereo images for processing in Parulski's cell phone. *See* APPL-1003, ¶52. A POSITA would have been motivated to incorporate Konno into Parulski's cell phone for several reasons.

First, Parulski does not provide lens prescription data for either the first or second fixed-focus lenses in its cell phone embodiment 600. Instead, Parulski simply refers to image assembly 610 as having a "first lens 612, preferably a fixed focal length wide angle lens (such as a 40 mm equiv. lens)" and "the second lens 616, preferably fixed focal length telephoto lens (such as 100 mm equiv. lens) …." APPL-1005, 23:36-41. Since Parulski provides no specific lens description or design parameters, a POSITA looking to implement the wide and telephoto dual-lens image assembly 610 in a cell phone embodiment would have needed to either find or design a suitable dual-lens system capable of producing stereo images in cell phone embodiment. APPL-1003, ¶57. For this reason alone, a POSITA would have looked to Konno which provides a fixed-focal length, dual-lens system

designed for digital equipment like cell phones, as indicated in Parulski's disclosure. *Id.*

While Parulski suggests 40 mm and 100 mm equivalent 35 mm focal length lenses as an option, a POSITA would have recognized that the preceding language "such as" that sets forth this suggestion would have meant that these 35 mm equivalent focal lengths are examples and not requirements for a dual-lens system that could be incorporated in Parulski's cell phone embodiment. *Id.*, ¶54.

Moreover, a POSITA would have recognized that Konno's dual-lens assembly is compatible with Parulski since Konno's system offers fixed-focal length wide and telephoto lenses in a thin format for incorporation in a mobile device. *See* APPL-1015, ¶46 ("The first and second imaging optical systems … are suitable for digital equipment having an image input function (for example, imaging apparatuses such as mobile phones with camera, and digital cameras), and can be combined with the imaging device ….").

Second, Parulski teaches the importance of keeping the "z" dimension (i.e., thickness) of its cell phone embodiment small, and notes the importance of selecting Wide and Telephoto lenses that reduces thickness. APPL-1005, 24:20-27 ("An important constraint in this embodiment is the "z" dimension 630, which must be held to a very small figure consistent with a cell phone layout and architecture."). Based on this, a POSITA looking to implement Parulski's

teachings would have been motivated to utilize Konno's dual-lens system because a POSITA would have recognized the benefits of Konno's thin profile at a reduced cost. *See* APPL-1015, ¶46 ("a thin and small-sized imaging optical units having high variable power and high performance, and digital equipment equipped with the imaging optical units can be realized at low costs."); *see also* APPL-1003, ¶56.

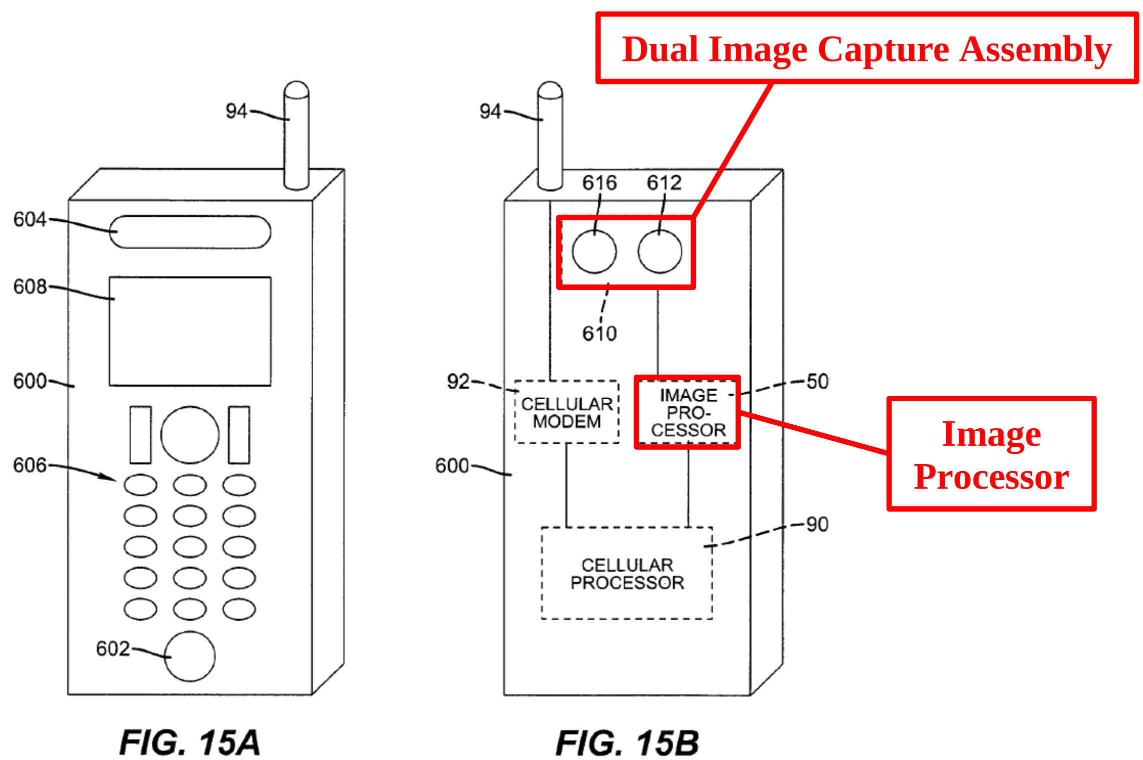
Thus, a POSITA would have been motivated to incorporate Konno's dual-lens system in Parulski's cell phone embodiment and would have reasonably expected success in doing so since both Parulski and Konno specify fixed-focus wide and telephoto lenses and Konno meets Parulski's need for lenses with reduced thickness suitable for processing to derive 3-dimensional data like a range map. *See* APPL-1003, ¶61; *see also* APPL-1005, Fig. 11, 19:49-20:15. Such a combination would have beneficially met Parulski's stated need for a thin dual-lens assembly appropriate for a cell phone but at a reduced cost, as stated in Konno. *See* APPL-1003, ¶57; APPL-1015, ¶46 ("By disposing the first and second imaging optical systems … a thin and small-sized imaging optical units having high variable power and high performance, and digital equipment equipped with the imaging optical units can be realized at low costs.").

As set forth below, the combination of Parulski and Konno renders obvious claims 1, 10-14, 16, 18, 23, 32-36, and 38, and 40.

4. Claim 1

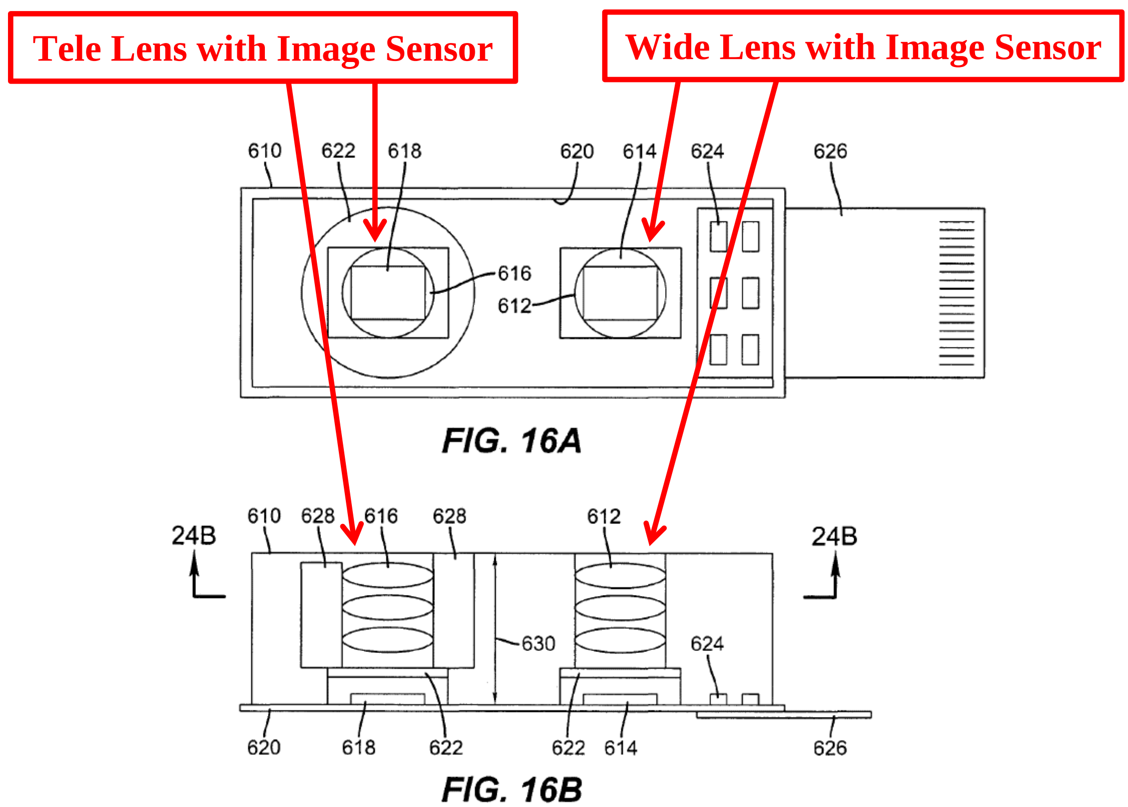
[1.0] "A dual-aperture digital camera for imaging an object or scene, comprising:"

The combination of Parulski and Konno renders [1.0] obvious. APPL-1003, p.36. First, Parulski teaches a digital camera in the form of a cell phone embodiment (*see* Fig. 15) that includes a dual image capture assembly 610 and an image processor 50. *See* APPL-1005, 23:4-12 ("as shown in FIG. 15A, a cell phone 600 includes a phone stage comprising … a cellular image capture assembly 610 connected via the image processor 50 …."). Fig 15A is below:



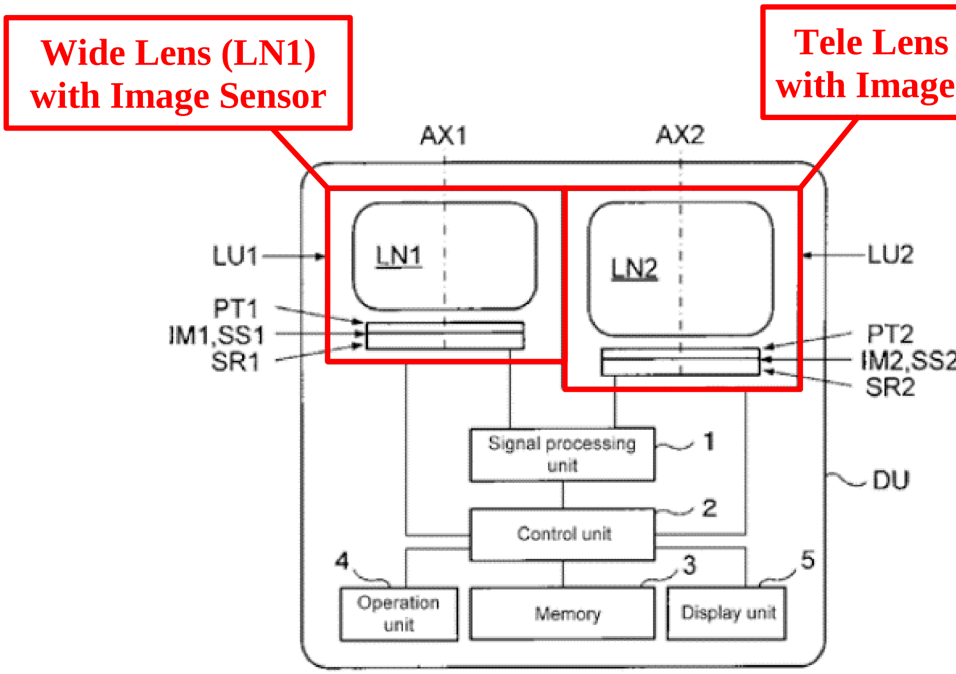
APPL-1005, Fig. 15A.

Parulski's cell phone is a "dual-aperture digital camera" because the image capture assembly 610 includes "a first fixed focal length lens 612 and a first image sensor 614, and a second fixed focal length lens 616 and a second image sensor 618." *Id.*, 23:33-36. The first lens 612 is "preferably a fixed focal length wide angle lens (such as a 40 mm equiv. lens)" and the second lens 616 is "preferably fixed focal length telephoto lens (such as 100 mm equiv. lens)." Both lenses are "oriented in the same direction" and capture images of the same scene but with different fields of view (FOVs). *See id.*, 23:40-43. Image assembly 610 from Figs. 16A and 16B are reproduced below:



Id., Figs. 16A, 16B (annotated).

Second, Konno similarly teaches a dual-aperture imaging system that also includes a wide-angle lens (i.e., shorter focal length) and a telephoto lens (i.e., longer focal length) represented in Fig. 21:



APPL-1015, Fig. 21 (annotated). As shown in Fig., 21, the lenses "LN1 and LN2 are single focus lenses that face the same direction." The LN2 lens has a focal length fm that is "longer than the focal length fw" of the LN1 lens. APPL-1015, ¶¶ 48-49. Because LN2 has a longer focal length, a POSITA would have understood Konno's lenses to have different FOVs. APPL-1003, p.40.

Third, as discussed above, a POSITA would have found it obvious to combine Konno's Example 2 with Parulski's cell phone camera. *Id.* Such a combination would have met Parulski's requirement for an image assembly with wide and telephoto fixed-focal-length lenses that produces images suitable for

stereo processing, but in a thin format appropriate for cell phones, as required by Parulski. *Id.* Thus, Parulski's cell phone combined with Konno's dual-lens system renders [1.0] obvious. *Id.*

[1.1] "a) a Wide camera comprising a Wide lens and a Wide image sensor, the Wide camera having a respective field of view FOV_W and being operative to provide a Wide image of the object or scene;"

The combination of Parulski and Konno renders this limitation obvious. First, as discussed above in [1.0] both Parulski and Konno teach dual-aperture cameras with Wide and Telephoto lenses. Konno further discloses that its "wide camera" includes a "wide lens and a wide image sensor" that provides a "wide image of the object or scene." APPL-1015, ¶49.

Second, a POSITA would have recognized that the LN1 lens in Konno's Example 2 as a "wide" lens. It provides a larger field of view (FOV_W = 76.18°) than the telephoto LN2 lens system (FOV_T = 55.52°) and a ratio of TTL/EFL (4.45/3.70) of less than one. *See* APPL-1003, p.41; APPL-1015, ¶76. Thus, Parulski combined with Konno's LN1 lens renders [1.1] obvious. *Id.*

[1.2] "b) a Telephoto camera comprising a Telephoto lens and a Telephoto image sensor, the Telephoto camera having a respective field of view FOV_T narrower than FOV_W and being operative to provide a Telephoto image of the object or scene, wherein the Telephoto lens has a respective effective focal length EFL_T and total track length TTL_T fulfilling the condition $EFL_T / TTL_T > 1$;"

The combination of Parulski and Konno renders [1.2] obvious. First, as discussed above in [1.0] both Parulski and Konno teach a dual-aperture camera

with Wide and Telephoto lenses. Konno further discloses a "telephoto camera" with a "telephoto image sensor" that provides a "telephoto image of the object or scene." APPL-1015, ¶49 ("The first and second imaging optical systems LN1 and LN2 are single focus lenses that face the same direction as described above and form the optical images IM1 and IM2 on the imaging faces SS1 and SS2 of the imaging devices SR1 and SR2, respectively.").

Second, a POSITA would have recognized Konno's LN2 lens system in Example 2 as a "telephoto" lens when compared to the LN1 lens system because LN2 provides a narrower field of view (FOV_W = 76.18° vs FOV_T = 55.52°) and has ratio of EFL/TTL (5.51/4.91) greater than one. APPL-1003, p.44-45; *see also* APPL-1015, ¶76. Thus, Parulski's cell phone combined with Konno's LN2 lens renders [1.2] obvious. APPL-1003, pp.42-44.

[1.3] "c) a first autofocus (AF) mechanism coupled mechanically to, and used to perform an AF action on the Wide lens;"

[1.4] "d) a second AF mechanism coupled mechanically to, and used to perform an AF action on the Telephoto lens; and"

The combination of Parulski and Konno renders [1.3]-[1.4] obvious because both references teach providing respective autofocus mechanisms for the Wide and Telephoto lens systems. *See id.*, p.43-46.

First, Parulski teaches that lens assembly 610 in its cell phone embodiment includes an autofocus mechanism for both the wide lens 612 and the telephoto lens

616. *Id.*, p.44. Specifically, Parulski states that "**both lenses 612 and 616 are adjustable focus lenses**" such that "**the sensor output from the telephoto lens 616 … generate[s] a focus detection signal for the wide angle lens 612"** and "**the sensor output from the wide angle lens 612 … generate[s] the focus detection signal for the telephoto lens 616**." *Id.*, 23:62-24:4. The focus detection is then applied to the autofocus subsystem 628 to adjust the focus of the respective lenses. *See id.*, 23:62-24:7. Because Parulski teaches generating a focus detection signal from either the Wide or Telephoto images that is then applied to an "autofocus subsystem" to adjust the focus, a POSITA would have understood that each lens system includes a mechanically coupled autofocus mechanism automatically controlled by the autofocus subsystem using a respective focus detection signal. *See* APPL-1003, p.44-45.

Second, Konno similarly teaches that it's dual-lens system includes an autofocus-drive mechanism for the LN1 and LN2 lenses. *See* APPL-1015, ¶50 ("[T]he first and second imaging optical systems **LN1 and LN2 have different focus movements** in the case of whole feeding."); APPL-1003, p.45. A POSITA would have understood "whole feeding" in this context to mean through a full range of focus distances. *Id.* Like Parulski's description above, Konno's autofocus mechanism is similarly adjusted by a controller. APPL-1015, ¶54 ("**The control**

<u>unit 2 is formed of a microcomputer, and controls various functions including</u> … **<u>a lens moving mechanism for focusing</u>**.”).

Because Konno teaches that the controller automatically adjusts the focus of each lens and that each lens has different focusing movements, a POSITA would have understood that each lens system’s focusing movement is mechanically coupled to its respective lens system to be automatically controlled. APPL-1003, p.46. A POSITA also would have understood that since both Parulski’s and Konno’s lenses include autofocus mechanisms, the combination of Parulski and Konno would likewise include autofocus mechanisms for each lens that would be automatically controlled by Parulski’s image processor 50 as discussed above. *Id.* Thus, Parulski’s cell phone with autofocuses lenses combined with Konno’s dual lens system also with autofocus lenses renders [1.3]-[1.4] obvious. *Id.*

<u>[1.5] “e) a camera controller operatively coupled to the first and second AF mechanisms and to the Wide and Telephoto image sensors and configured to control the AF mechanisms”</u>

Parulski discloses [1.5] because it teaches that processor 50 (e.g., a camera controller) included in the cell phone controls the autofocus mechanism on each lens. *Id.*, p.46-47. More specifically, as discussed above in [1.3] and [1.4], Parulski teaches that “both lenses 612 and 616 are adjustable focus lenses” such that “the image processor 50 … uses the sensor output from the telephoto lens 616 to generate a focus detection signal for the wide angle lens 612 or … uses the sensor

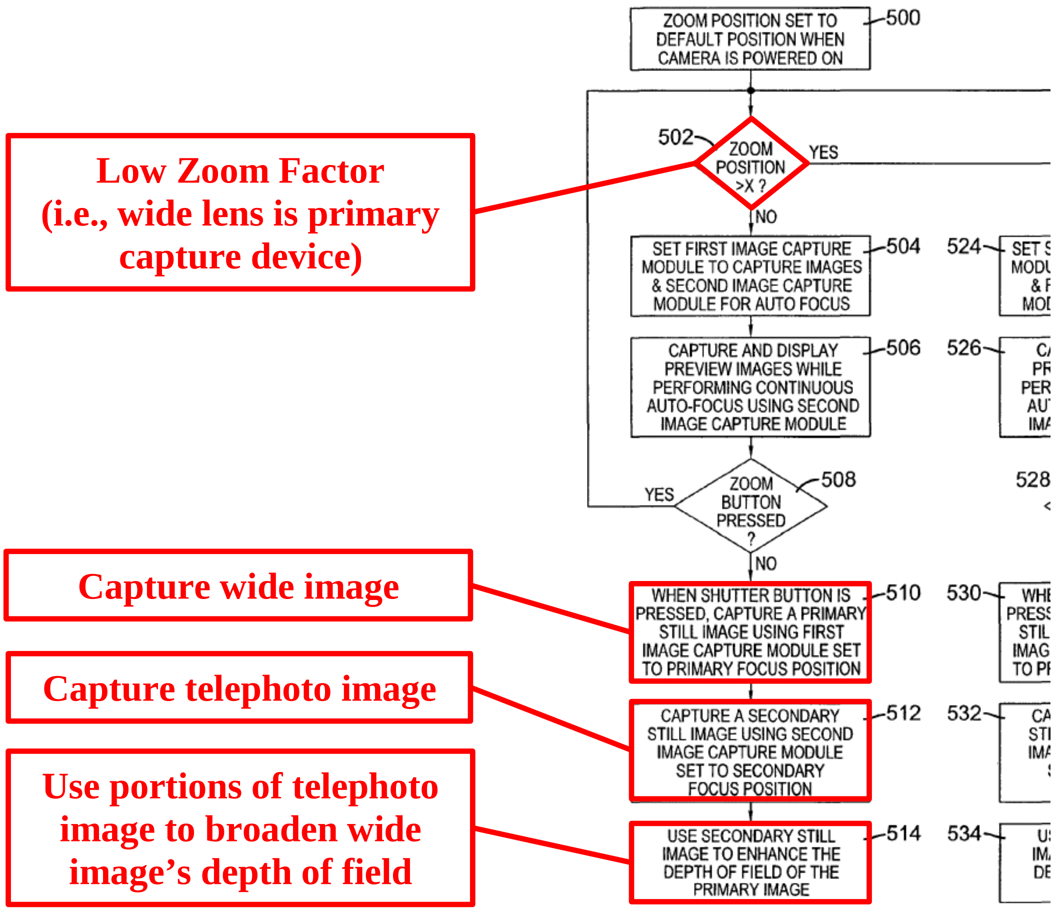
output from the wide angle lens 612 to generate the focus detection signal for the telephoto lens 616." APPL-1005, 23:62-24:4. The focus detection signal is then applied to the autofocus subsystem 628 to adjust the focus of the respective lens. *Id.*; *see* APPL-1005, 23:62-24:7.

A POSITA would have understood that Parulski's teaching of image processor 50 (i.e., a camera controller) using sensor output from one lens to generate a focus detection signal for the other lens that is then applied to an autofocus subsystem means that the processor is operatively coupled to each autofocus mechanism to control the autofocus based on the focus detection signal. APPL-1003, p.47. Thus, Parulski's image processor 50 that controls an autofocus mechanism renders this limitation obvious. *Id.*

[1.5.1] "and to process the Wide and Telephoto images to create a fused image, wherein areas in the Telephoto image that are not focused are not combined with the Wide image to create the fused image"

Parulski renders [1.5.1] obvious because, in reference to Fig. 14, it teaches an image enhancement method where, via image processor 50, "an image is captured from the primary capture unit at one focus position" (e.g., the wide lens, *see* Fig. 14, block 510) and "another image is captured from the scene analysis capture unit (the secondary image capture unit) at another focus position" (e.g., the telephoto lens, *see* Fig. 14, block 512). APPL-1005, 28:45-57. "**Then, the two images are combined into a modified image with a broadened depth of field**."

Id.; *see also id.*, 22:14-42. This process is annotated in Fig. 14 below:



APPL-1003, p.48; APPL=1005, Fig. 14, in part, (annotated).

Because Parulski teaches that the enhanced image has a "broadened depth of field," a POSITA would have understood this to mean that when the primary image is from the wide lens (*see* Fig. 14, block 510) and the secondary image is from the telephoto lens (*see* Fig. 14, block 512), the focused portions of the telephoto image are identified and combined with the wide image to broaden the wide image's depth of field (*see* Fig. 14, block 514). APPL-1003, p.48-49.

Parulski offers an example of this where a wide image is focused on a

mountain range, a telephoto image is focused on a dog, and the images are combined so that both the mountains and the dog are in focus (i.e., creating a broader depth of field). APPL-1005, 21:34-44 ("For example, **the dog and mountains, albeit they are at opposite range extremes, could be brought in focus because they are the regions of interest** ...."). For this example, Parulski teaches using a range map "to improve object identification within the image by identifying the continuous boundaries of the object so the shape of the object can be define" and "**to enable object extraction from an image by identifying the continuous boundaries of the object so it can be segmented within the image**." APPL-1005, 20:50-59.

Based on Fig. 14 and the example that Parulski provides of having an image of mountains captured at one extreme focus distance (i.e., the wide image focused on the mountains) and the image of a dog captured at the other extreme focus distance (i.e., the telephoto image focused on the dog), a POSITA would have understood that creating an enhanced image with both the mountains and the dog in focus would have meant that the pixel corresponding to the dog from the telephoto image would have been identified by the range mapping process and then fused with the corresponding pixels in the wide image so that the dog would be sharpened in the wide image while maintaining the mountains in focus, thus broadening the wide image's depth of field. APPL-1003, p.50. Because the dog

from the telephoto image is fused with the wide image, a POSITA would have understood this to mean than only the portions that are in-focus (i.e., the dog) are fused with the wide image. *Id.* Otherwise, the wide image's depth of field would not be broadened if out-of-focus portions of the telephoto image are also fused. *Id.*

Thus, Parulski's cell phone camera that combines in-focus portions of a telephoto image with a wide image to broaden the depth of field of the wide image teaches [1.5.1].

[1.5.2] "and wherein the camera controller is further operative to output the fused image with a point of view (POV) of the Wide camera by mapping Telephoto image pixels to matching pixels within the Wide image."

Parulski renders [1.5.2] obvious. First, as discussed above in [1.5.1], Parulski teaches an image enhancement process where in-focus portions of the telephoto image are combined with the wide image to broaden the wide image's depth of field. *Id.*; *see* APPL-1005, 22:14-42, 28:45-57, Fig. 14. A POSITA would have understood that fusing portions of the telephoto image with the wide image (as annotated in Fig. 14 above) would have otherwise maintained the wide image, therefore outputting a fused image with the wide image's field of view. APPL-1003, pp.50-51.

Second, as discussed above in [1.5.1], Parulski teaches that its fusion process is performed, in part, by using a range map "to improve object identification within the image by identifying the continuous boundaries of the object so the shape of

the object can be defined" and "**to enable object extraction from an image by identifying the continuous boundaries of the object so it can be segmented within the image**." APPL-1005, 20:50-59.

Parulski's range map is generated by matching pixels from the telephoto image to matching pixels in the wide image. APPL-1005, 20:1-15 ("**Then, in block 480, the second autofocus image is correlated with the cropped 10 and upsampled image to determine the pixel offset between the images for different portions of the images**"). Parulski thus teaches outputting a fused image by mapping pixels from the telephoto image to matching pixels in the wide image. APPL-1003, p.51-52. Thus, Parulski's cell phone that matches pixels from the telephoto image to pixels in the wide image which is then used to enhance the wide image's depth of field teaches [1.5.2].

5. Claim 10

[10.0] "The dual-aperture digital camera of claim 1, wherein the Wide and Telephoto image sensors have pixels with identical pixel counts."

The combination of Parulski and Konno renders [10.0] obvious because as shown in Table 1, the LN1 and LN2 lenses in Konno's Example 2 both utilize image sensors with identical 13-megapixel pixel counts:

		Example 1		Example 2	
		LN1	LN2	LN1	LN2
Focal Length of Entire System (mm)	fw or fm	2.73	4.32	3.70	5.51
Fno	FNOw or FNOm	4.00	4.00	3.00	4.00
Lens Entire Length (at infinite) (mm)	TLw or TLm	3.04	3.65	4.45	4.91
Maximum Image Height (mm)	2Y'	5.12	5.12	5.80	5.80
Entire Viewing Angle (deg)	2ωw or 2ωm	86.32	61.28	76.18	55.52
L1 Focal Length (mm)	f1w or f1m	2.60	2.10	2.47	2.54
L2 Focal Length (mm)	f2w or f2m	-7.91	-5.51	-3.53	-4.02
L3 Focal Length (mm)	f3w or f3m	3.14	-13.70	13.47	22.96
L4 Focal Length (mm)	f4w or f4m	-1.68	-3.09	2.42	-5.99
L5 Focal Length (mm)	F5w or f5m	--	--	-1.84	-7.73
Composite Focal lengths of L1 and L2 (mm)	fFw or fFm	3.48	2.91	5.48	4.84
Focal Length of Lens LX (mm)	fXw or fXm	3.14	-13.70	2.42	-5.99
Number of Pixels od Sensor (MagaPixels)	PX	10.00	10.00	13.00	13.00
Cropped Minimum Number of Pixels (MagaPixels)		4.00	4.00	5.86	5.86
Cropped Maximum Focal Length (mm)		4.32	6.83	5.51	8.21
Electronic Zoom Ratio (Power)	ZR		2.50		2.22
Focal Length (135 Conversion) (mm)		23.07	36.52	27.60	41.10

Image Sensors with Identical Number of Pixels

APPL-1003, p.53; APPL-1015, ¶76 (annotated).

Thus, Parulski's cell phone embodiment combined with Konno's dual-lens assembly that uses a 13-megapixel image sensor in each lens system renders [10.0] obvious.

6. Claim 11

[11.0] "The dual-aperture digital camera of claim 10, wherein the pixel count is 12 MP."

The combination of Parulski and Konno renders [11.0] obvious. First, Parulski teaches that various types and sizes of sensors may be used in its cell phone embodiment. APPL-1005, 13:27-36 ("image sensors 12 and 14 may have a

variety of aspect ratios, for example, a 4:3 image aspect ratio and a variety of resolutions …. It should also be understood that the image sensors 12 and 14 do not have to have the same specifications.”).

Second, Konno teaches using at least a 10 MP image sensor to obtain high-quality images. APPL-1015 ¶21 (“To acquire an excellent image, also when the electronic zoom is performed, a sufficient number of pixels are required…. [T]o acquire the above-mentioned number of pixels, an imaging device (that is, a large-sized sensor) having **a large number of pixels such as 10 megapixels is required**.”). As discussed above in [10.0], Konno teaches also using a 13 MP image sensor in the Example 2 embodiment. *See id.*, Table 1.

Based on Parulski’s teaching of its embodiments using image sensors of various types and sizes and Konno’s teaching of needing an image sensor of at least 10 MP for high quality imaging (and providing an embodiment using 13 MP sensors), a POSITA would have found it obvious that a 12 MP (4000x3000) sensor could likewise be used for capturing high-quality images in Konno’s dual-lens system. APPL-1003, p.55. One such sensor that was available and could have been used with Konno’s Example 2 system due to have a similar image diagonal is the Sony ICX612 image sensor for digital imaging having a pixel count of 12 MP. *Id.*; *see* APPL-1031, p.1

A POSITA thus would have found it obvious to use an image sensor in Konno that outputs a high resolution like the ICX612 sensor simply based on Konno's teaching of using a sensor larger than 10 MP to maintain high image quality. APPL-1003, p.55. Thus, Parulski's cell phone embodiment combined with Konno's requirement for an image sensor lager than 10 MP renders [11.0] obvious.

7. Claim 12

[12.0] "The dual-aperture digital camera of claim 1, wherein the Wide and Telephoto image sensors have pixels with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ and wherein Pixel size$_{Wide}$ is equal to Pixel size$_{Tele}$."

The combination of Parulski and Konno renders this [12.0]. First, as discussed above in [10.0] Konno teaches that the image sensors in its Example 2 embodiment have identical pixel counts of 13.0 megapixels. Second, Konno further teaches that each image sensor is 5.8 mm high:

Image Sensor Height

		Example 1		Example 2	
		LN1	LN2	LN1	LN2
Focal Length of Entire System (mm)	fw or fm	2.73	4.32	3.70	5.51
Fno	FNOw or FNOm	4.00	4.00	3.00	4.00
Lens Entire Length (at infinite) (mm)	TLw or TLm	3.04	3.65	4.45	4.91
Maximum Image Height (mm)	2Y'	5.12	5.12	5.80	5.80
Entire Viewing Angle (deg)	2ωw or 2ωm	86.32	61.28	76.18	55.52
L1 Focal Length (mm)	f1w or f1m	2.60	2.10	2.47	2.54
L2 Focal Length (mm)	f2w or f2m	-7.91	-5.51	-3.53	-4.02
L3 Focal Length (mm)	f3w or f3m	3.14	-13.70	13.47	22.96
L4 Focal Length (mm)	f4w or f4m	-1.68	-3.09	2.42	-5.99
L5 Focal Length (mm)	F5w or f5m	--	--	-1.84	-7.73
Composite Focal lengths of L1 and L2 (mm)	fFw or fFm	3.48	2.91	5.48	4.84
Focal Length of Lens LX (mm)	fXw or fXm	3.14	-13.70	2.42	-5.99
Number of Pixels od Sensor (MagaPixels)	PX	10.00	10.00	13.00	13.00
Cropped Minimum Number of Pixels (MagaPixels)		4.00	4.00	5.86	5.86
Cropped Maximum Focal Length (mm)		4.32	6.83	5.51	8.21
Electronic Zoom Ratio (Power)	ZR		2.50		2.22
Focal Length (135 Conversion) (mm)		23.07	36.52	27.60	41.10

Image Sensor # of Pixels

APPL-1003, p.56; APPL-1015, ¶76 (annotated).

Since each sensor in Example 2 is 13-megapixel and 5.8 mm high, a POSITA would have recognized that the sensors have not only the same number of pixels but also the same physical dimensions and therefore identical pixel widths (since pixels are square, pixel heights would also be the identical). APPL-1003, p.56. Thus, Parulski's cell phone combined with Konno's dual-lens assembly with image sensors having the same dimensions and pixel counts renders [12.0] obvious.

8. Claim 13

[13.0] "The dual-aperture digital camera of claim 1, wherein the Wide and Telephoto image sensors have pixels with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ and wherein Pixel size$_{Wide}$ is not equal to Pixel size$_{Tele}$."

The combination of Parulski and Konno renders [13.0] obvious. First, Parulski teaches that sensors used in the Wide and Telephoto lens systems "**may have a variety of aspect ratios, for example, a 4:3 image aspect ratio and a variety of resolutions**." APPL-1005, 13:27-36. Parulski also explains that "**the image sensors 12 and 14 do not have to have the same specifications**." *Id.* Second, Konno teaches using a sensor having "**a sufficient number of pixels**" and that "**to acquire the above-mentioned number of pixels, an imaging device (that is, a large-sized sensor) having a large number of pixels such as 10 megapixels is required**" for high performance. APPL-1015 ¶21.

Based on these teachings, a POSITA could have selected compatible sensors with different sizes or resolution. APPL-1003, p.58. Two commonly available prior art sensors of which a POSITA would have been aware and sought to use in devices like Parulski and Konno (due to having a high pixel count and similar diagonal) were the Sony ICX612 with about 12 MP and the ICX652 with about 13.5 MP. *Id.*; *see* APPL-1031; APPL-1032. Both sensors are the same size but by having different resolutions, the ICX 612 has a pixel width of 1.85 μm and the ICX652 has a pixel width of 1.75 μm. *See* APPL-1031; APPL-1032. Using these

sensors with Konno's lens design would have thus yielded a dual-lens imaging system having with image sensors having different pixel widths. APPL-1003, p.58.

Thus, based on Parulski's teachings that the image sensors in its embodiments can have different resolutions, Konno's teaching of using image sensors of 10 MP or greater, and the availability of compatible sensors of similar size but different pixel widths renders [13.0] obvious.

9. Claim 14

[14.0] "The dual-aperture digital camera of claim 1, wherein the Wide and Telephoto lenses have different F numbers F#$_{Wide}$ and F#$_{Telephoto}$."

The combination of Parulski and Konno renders [14.0] obvious because as shown in Table 1, the LN1 and LN2 lenses in Konno's Example 2have different F numbers (LN1: F#$_{Wide}$ = 3.0) and (LN2: F#$_{Telephoto}$ = 4.0):

		Example 1		Example 2	
		LN1	LN2	LN1	LN2
Focal Length of Entire System (mm)	fw or fm	2.73	4.32	3.70	5.51
Fno	FNOw or FNOm	4.00	4.00	3.00	4.00
Lens Entire Length (at infinite) (mm)	TLw or TLm	3.04	3.65	4.45	4.91
Maximum Image Height (mm)	2Y'	5.12	5.12	5.80	5.80
Entire Viewing Angle (deg)	2ωw or 2ωm	86.32	61.28	76.18	55.52
L1 Focal Length (mm)	f1w or f1m	2.60	2.10	2.47	2.54
L2 Focal Length (mm)	f2w or f2m	-7.91	-5.51	-3.53	-4.02
L3 Focal Length (mm)	f3w or f3m	3.14	-13.70	13.47	22.96
L4 Focal Length (mm)	f4w or f4m	-1.68	-3.09	2.42	-5.99
L5 Focal Length (mm)	F5w or f5m	--	--	-1.84	-7.73
Composite Focal lengths of L1 and L2 (mm)	fFw or fFm	3.48	2.91	5.48	4.84
Focal Length of Lens LX (mm)	fXw or fXm	3.14	-13.70	2.42	-5.99
Number of Pixels od Sensor (MagaPixels)	PX	10.00	10.00	13.00	13.00
Cropped Minimum Number of Pixels (MagaPixels)		4.00	4.00	5.86	5.86
Cropped Maximum Focal Length (mm)		4.32	6.83	5.51	8.21
Electronic Zoom Ratio (Power)	ZR		2.50		2.22
Focal Length (135 Conversion) (mm)		23.07	36.52	27.60	41.10

Tele F#

Wide F#

APPL-1015, ¶76 (annotated).

Thus, Parulski's cell phone combined with Konno's dual-lens system renders [14.0] obvious.

10. Claim 16

[16.0] "The dual-aperture digital camera of claim 14, wherein the camera controller is further configured to synchronize the Wide and Telephoto image sensors to start exposure at the same time."

Parulski renders [16.0] obvious because it teaches both cameras capturing images (i.e., starting exposure) simultaneously. *See* APPL-1005, 12:9-20. ("a second image sensor, is used to **simultaneously capture** a second (i.e., secondary) still image at a second (i.e., secondary) focus distance."); *Id.*, 30:1-11 ("Simultaneously, the secondary capture stage is set for a relatively fast exposure…"). A POSITA would have understood that "simultaneous capture" means that exposure of each image sensor surface starts at the same time. *See* APPL-1034, 1:21-23 ("two independent offset cameras with coordinated shutters are used to **simultaneously expose two frames of film**."). APPL-1003, p.60.

When applied to Parulski's cell phone camera, a POSITA would have understood that both the Wide and Telephoto lenses would have been synchronized by the image processor 50 (i.e., a camera controller) to expose each image sensor surface at the same time to facilitate simultaneous capture. *Id.* p.61. Thus, Parulski's renders [16.0] obvious.

11. Claim 18

[18.0] "The dual-aperture digital camera of claim 1, wherein the Wide and Telephoto lenses have respective F numbers $F\#_{Wide}$ and $F\#_{Telephoto}$ and"

Konno discloses [18.0] because it teaches, as discussed above in [14.0], the Example 2 LN1 lens (i.e., Wide) has an F# of 3.0 and the LN2 lens (i.e., Telephoto) has an F# of 4.0. *See* APPL-1005, Table 1.

[18.1] "wherein the camera controller is further configured to set respective Wide and Telephoto image sensor exposure times ET_{Wide} and ET_{Tele} to be equal."

Parulski renders [18.0] obvious because it teaches an "alternate" embodiment that uses different exposure times for each camera to achieve different noise levels or motion blur. *Id.*, 30:1-4 ("In a further embodiment of the invention, the **primary capture stage and secondary capture stage are set for different exposure times so that different levels of noise and motion blur are present in the respective images**."). Since Parulski teaches using different exposure times in an alternate embodiment, a POSITA would have understood that the main embodiment includes setting the same exposure time for each camera so that both images maintain the similar levels of noise and motion blur. APPL-1003, p.62. Thus, the combination of Parulski and Konno renders [18.0] obvious.

12. Claim 23

[23.0] "A method comprising:"

Parulski discloses a method of enhancing an image based on a wide and telephoto image as discussed above in [1.0-1.5.2]. *Id.*

[23.1] "a) providing a dual-camera comprising a Wide camera and a Telephoto camera, the Wide and Telephoto cameras having respective Wide and Telephoto lenses, Wide and Telephoto image sensors and Wide and Telephoto fields of view FOV_W and FOV_T, wherein FOV_T is narrower than FOV_W, wherein the Telephoto lens has a respective effective focal length EFL_T and total track length TTL_T fulfilling the condition $EFL_T / TTL_T > 1$"

This limitation is substantially similar to [1.0-1.2] that provides a dual-aperture camera with Wide and Telephoto cameras. *Id.* As discussed above in [1.2], the Wide and Telephoto cameras have respective fields of view (FOV) where the FOV of the telephoto camera is narrower than the FOV of the wide camera. *Id.* Thus, this limitation is rendered obvious as discussed above.

[23.2] "b) acquiring a Wide image with the Wide sensor and a Telephoto image with the Telephoto sensor;"

This limitation is substantially similar to [1.1] and [1.2] that each recite providing an image with the Wide and Telephoto cameras. *Id.*, p.63. A POSITA would have recognized that "acquiring" an image with the Wide and Telephoto cameras is indistinguishable from the Wide and Telephoto cameras "providing" images. *Id.* This limitation is thus rendered obvious as discussed above.

[23.3] "c) processing the Wide and Telephoto images to create a fused image, wherein areas in the Telephoto image that are not focused are not combined with the Wide image to create the fused image; and"

This limitation is substantially similar to [1.5.1] and is rendered obvious as discussed above. *Id.*

[23.4] "d) outputting the fused image with a point of view (POV) of the Wide camera by mapping Telephoto image pixels to matching pixels within the Wide

image."

This limitation is substantially similar to [1.5.2] and is rendered obvious as discussed above. *Id.*

13. Claim 32

[32.0] "The method of claim 23, wherein the Wide and Telephoto image sensors have pixels with identical pixel counts."

This limitation is substantially similar to [10.0] and is rendered obvious as discussed above. *Id.*, p.64.

14. Claim 33

[33.0] "The method of claim 32, wherein the pixel count is 12 MP."

This limitation is substantially similar to [11.0] and is rendered obvious as discussed above. *Id.*

15. Claim 34

[34.0] "The method of claim 23, wherein the Wide and Telephoto image sensors have pixels with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ and wherein Pixel size$_{Wide}$ is equal to Pixel size$_{Tele}$."

This limitation is substantially similar to [12.0] and is rendered obvious as discussed above. *Id.*

16. Claim 35

[35.0] "The method of claim 23, wherein the Wide and Telephoto image sensors have pixels with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ and wherein

Pixel size$_{Wide}$ is not equal to Pixel size$_{Tele}$."

This limitation is substantially similar to [13.0] and is rendered obvious as discussed above. *Id.*

17. Claim 36

[36.0] "The method of claim 23, wherein the Wide and Telephoto lenses have different F numbers F#$_{Wide}$ and F#$_{Telephoto}$."

This limitation is substantially similar to [14.0] and is rendered obvious as discussed above. *Id.*, p.65.

18. Claim 38

[38.0] "The method of claim 36, further comprising synchronizing the Wide and Telephoto image sensors to start exposure at the same time."

This limitation is substantially similar to [16.0] and is rendered obvious as discussed above. *Id.*

19. Claim 40

[40.0] "The method of claim 23, wherein the Wide and Telephoto lenses have respective F numbers F#$_{Wide}$ and F#$_{Telephoto}$, the method further comprising setting respective Wide and Telephoto image sensor exposure times ET$_{Wide}$ and ET$_{Tele}$ to be equal."

This limitation is the same as [18.0]-[18.1] and is rendered obvious as discussed above. *Id.*

B. Ground 2: Claims 2-4 and 24-26 are obvious under § 103 over Parulski, Konno, and Szeliski.

1. Summary of Szeliski

Szeviski is a textbook "suitable for teaching a senior-level undergraduate course in computer vision to students in both computer science and electrical engineering." APPL-1013, Preface. Chapter 11 discusses "Stereo Correspondence" which teaches a method for deriving a range or depth map to "estimat[e] a 3D model of the scene by finding matching pixels in the images and converting their 2D positions into 3D depths." *Id.*, p.535. As part of Szeliski's method, epipolar geometry is used to compute a pixel's correspondence in another image. *See id.*, p.537. This allows for rectification of the images along an epipolar line which, when performed prior to image registration, provides for a more efficient algorithm for registration and distance calculations. *See id.*, p.538-39.

2. Reasons to combine Parulski, Konno, and Soga

A POSITA would have found it obvious to combine Parulski, Konno, and Szeliski because such a combination would have been nothing more than using Szeliski's step of first rectifying images along epipolar lines (*id.*, p.538) to improve Parulski's range mapping process in the same way. APPL-1003, ¶60

Specifically, as discussed above, Parulski teaches using wide and telephoto lenses in a dual aperture camera to generate images suitable for calculating a range map. *See* APPL-1005, 19:49-20:24 ("FIG. 11 depicts a flow diagram showing a

method for processing images captured using the image capture assemblies of FIG. 3 or 8, wherein a range map is produced."). Parulski's process determines pixel offsets for a disparity map (i.e., registration map) which then allows for the determination of distances within the scene (i.e., a range/depth map). *See id.*, 19:49-20:6.

Szeliski improves upon Parulski's image processing technique by showing that first rectifying the images based on epipolar geometry makes the registration and depth mapping process more efficient. *See* APPL-1013, p.538 ("A more efficient algorithm can be obtained by first rectifying (i.e., warping) the input images so that corresponding horizontal scanlines are epipolar lines …."). Because both Parulski and Szeviski teach calculating distance information between stereo images and Szeliski teaches that the process can be made more efficient by first rectifying the images along an epipolar line, a POSITA would have sought to add an epipolar rectification process (e.g., such as Szeliski's) to Paruskli's range mapping algorithm. APPL-1003, ¶62.

Such a combination would have been understood to provide Parulski with the same result of a more efficient image range mapping algorithm. *See id.*, ¶63; APPL-1013, p.538. Since efficiency is always better in computer processing, POSITAs would have sought to add Szeliski's suggested rectification step to Parulski's method and would have had reasonable success in doing so since both

describe implementing image processing in software. *See* APPL-1005, 9:65-10:10; APPL-1013, p.538-40.

The following analysis show how the combination of Parulski, Konno, and Szeliski renders obvious claims 2-4 and 24-26.

3. Claim 2

[2.0] "The dual-aperture digital camera of claim 1, wherein the camera controller is further configured to perform rectification of the Wide and Telephoto images by aligning these images to be on an approximately epipolar line to obtain rectified Wide and Telephoto images."

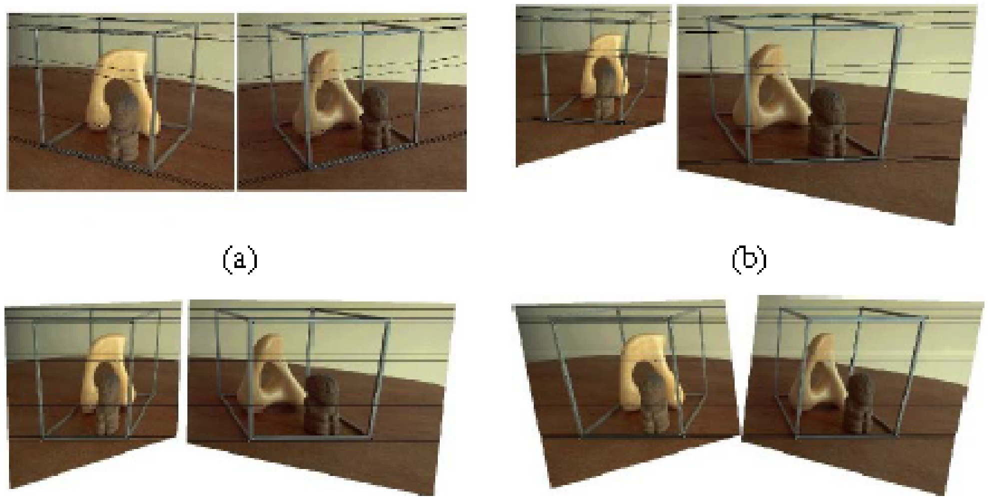
The combination of Parulski and Szeliski renders [2.0] obvious. First, as discussed above in [1.5.1] and [1.5.2], Parulski teaches performing an image enhancement technique where portions of the Telephoto image are identified and combined with the Wide image to broaden the wide image's field of view. APPL1003, p.68; *see* APPL-1005, 20:50-21:6, 28:32-40, Fig. 14.

The process of identifying the portions of the Telephoto image to fuse with the Wide image uses a range map to match pixels from the Telephoto image to corresponding pixels in the Wide image. APPL-1003, p.68; *see* APPL-1005, 20:1-15, Fig. 11(set forth in Fig. 11). This matching process includes up-sampling and cropping the Wide image (i.e., shorter focal length) before correlating it with the Telephoto image (i.e., longer focal length) to determine pixel offsets. APPL-1005, 20:1-15 ("the second autofocus image is correlated with the cropped and upsampled image to **determine the pixel offset between the images for different**

portions of the images. The pixel offsets are then converted in block 482 to distances from the image capture device using the autofocus rangefinder calibration curve."). A POSITA would have recognized that Parulski's process of correlating the Wide and Telephoto images to determine pixel offsets that are converted to distances creates a registration map. APPL-1003, pp.68-69.

Second, Szeliski teaches that Parulski's range mapping technique can be made more efficient by first rectifying the two images along an epipolar line. APPL-1003, p.69. Specifically, Szeliski teaches that "epipolar geometry for a pair of cameras is implicit in the relative pose and calibrations of the cameras…." APPL-1013, p.538. Szeliski teaches that once this geometry is computed, "**we can use the epipolar line corresponding to a pixel in one image to constrain the search for corresponding pixels in the other image**." *Id.* Thus, "[a] **more efficient algorithm can be obtained by first *rectifying* (i.e., warping) the input images so that corresponding horizontal scanlines are epipolar lines** …." *Id.*

Szeliski's Figure 11.4 offers a visual example of rectifying two images along epipolar lines:



(a) (b) (c) (d)

Figure 11.4 The multi-stage stereo rectification algorithm of Loop and Zhang (1999) © 1999 IEEE. (a) Original image pair overlaid with several epipolar lines; (b) images transformed so that epipolar lines are parallel; (c) images rectified so that epipolar lines are horizontal and in vertial correspondence; (d) final rectification that minimizes horizontal distortions.

APPL-1013, p.539 (Fig. 11.4).

A POSITA would have recognized that applying Szeliski's rectification step to Parulski's image processing on the cell phone camera would yield rectified Wide and Telephoto images. APPL-1003, p.71. A POSITA also would have understood that these rectified images would then be used in Parulski's method for performing more efficient pixel matching in deriving the range map. *Id.* Further, as discussed above, a POSITA would have found it obvious to improve Parulski's image processing method by first rectifying the images along an epipolar line, as described in Szeliski. *Id.* Adding Szeliski's rectification step in Parulski's range mapping method would have provided the same benefit as described in Szeliski of

achieving a more efficient method for determining corresponding pixel between the Wide and Telephoto images. *Id.*, pp.71-72.

Thus, the Parulski's range mapping method combined with Szeliski's step for first rectifying images renders [2.0] obvious.

4. Claim 3

[3.0] "The dual-aperture digital camera of claim 2, wherein the camera controller is further configured to perform mapping between the rectified Wide and Telephoto images to produce a registration map."

The combination of Parulski and Szeliski renders [3.0] obvious. First, as shown above in [2.0], the combination of Parulski and Szeliski renders obvious first rectifying Wide and Telephoto images as part of Parulski's range mapping method. *Id.*, p.72. Second, as also discussed above in [2.0], a POSITA would have understood Parulski range mapping method to include deriving a registration map by determining pixel offsets between the images. *Id.*; APPL-1005, 20:8-15 ("Then, in block 480, the second autofocus image is correlated with the cropped and upsampled image **to determine the pixel offset between the images for different portions of the images**."). This is consistent with the '479 Patent that similarly derives a registration map by determining pixel offsets. *See* APPL-1001, 12:4-9 ("registration is performed between the Wide and Telephoto images to output a transformation coefficient.… The transformation coefficient includes the

translation between matching points in the two images. This translation can be measured in a number of pixels.").

Thus, Parulski's range mapping method that determines pixel offsets combined with Szeliski's technique of rectifying images before determining pixel offsets renders [3.0] obvious. APPL-1003, p.73.

5. Claim 4

[4.0] "The dual-aperture digital camera of claim 3, wherein the camera controller is further configured to perform resampling of the Telephoto image according to the registration map to provide a re-sampled Telephoto image."

The combination of Parulski and Szeliski renders [4.0] obvious. First, as discussed above in [3.0], a POSITA would have recognized that Parulski's range mapping method that determines pixel offsets between corresponding portions of the images creates a "registration map." *Id.* Second, Parulski renders obvious resampling the Telephoto image according to the registration map because, for example, as discussed above in [1.5.1-1.5.2], Parulski teaches an image enhancement process that combines portions of the Telephoto image with the Wide image in order to output an enhanced image with the wide image's field of view having a broadened depth of field. *Id.*; *see* APPL-1005, 20:14-42, Fig. 14, 28:45-53 ("Then, the two images are combined into a modified image with a broadened depth of field.").

When applied to Parulski's cell phone embodiment as discussed above in [1.0] (i.e., two cameras with different focal lengths), a POSITA would have understood this "combination" of the two images to require a down-sampling of the Telephoto image so that portions of the Telephoto image are of similar size to corresponding portions of the Wide image for combination. APPL-1003, p.74. Otherwise, the fused portions of the Telephoto image (with a longer focal length and narrower FOV) would not be correctly size for combination with the Wide image (with a shorter focal length and wider FOV). *Id.*

A POSITA also would have recognized that this down-sampling would have been performed according to a registration map (i.e., determined pixel offsets) discussed above in [3.0] because Parulski teaches performing this type of image enhancement using the range map derived from determined pixel offsets. *Id.*; *see* APPL-1005, 20:50-21:6 ("The range map is then used to modify … the output image for a variety of purposes, such as … : a) to improve object identification … ; b) to enable object extraction … ; g) to improve scene balance … by enabling objects in the foreground to be emphasized.").

In other words, a POSITA would have understood that Parulski's image enhancement method—that combines portions of the Telephoto image with the Wide image—would have (1) used a range map to determining down-sampling size for the Telephoto image based on object identification, (2) used the range map

to extract the foreground object from the Telephoto image for combination with the Wide image, and (3) emphasized the foreground object in the Wide image by fusing with corresponding pixels in the down-sampled Telephoto image. *Id.*, pp.75-76. Accordingly, a POSITA would have understood that Parulski's method of combining Telephoto portions with the Wide image would have included down-sampling the Telephoto image according to a registration map. *Id.*

Thus, Parulski's image processing technique of combining portions of the Telephoto image with the Wide image renders [4.0] obvious.

6. Claim 24

[24.0] "The method of claim 23, further comprising rectifying the Wide and Telephoto images by aligning these images to be on an approximately epipolar line to obtain rectified Wide and Telephoto images."

This limitation is substantially similar to [2.0] and is rendered obvious as discussed above. *Id.*

7. Claim 25

[25.0] "The method of claim 24, further comprising mapping between the rectified Wide and Telephoto images to produce a registration map."

This limitation is substantially similar to [3.0] and is rendered obvious as discussed above. *Id.*

8. Claim 26

[26.0] "The method of claim 25, further comprising resampling the Telephoto image according to the registration map to provide a re-sampled Telephoto

image."

This limitation is substantially similar to [4.0] and is rendered obvious as discussed above. *Id.*, p.77.

C. Ground 3: Claims 5-9 and 27-31 are obvious under § 103 over Parulski, Konno, Szeliski, and Segall.

1. Summary of Segall

Segall describes an image processing method with two phases—a registration phased for building a registration map and a fusion phase for fusing an enhancement image with a reference image based on the registration map. *Id.*, ¶65; *See* APPL-1024, 3:15-16 ("These systems and methods typically comprise two basic phases: registration and fusion."). The registration phase transforms a sequence of images "to a sequence of registered frame-sets, where each frame-set corresponds to a specific point in time and may comprise an auto-exposure frame and one or more aligned enhancement frames." APPL-1024, 3:18-23. Segall's registration phase can include "global motion estimation, image warping and interpolation as well as other methods." APPL-1024, 3:17-18.

The fusion phase "performs the fusion process, which may result in outputting an EDR sequence." APPL-1024, 3:23-25. Fusion is performed "at each time point individually, and may comprise a mismatch detector which may restrict or exclude areas containing local motion and other registration errors from the fusion process." APPL-1024, 3:25-28. "The goal of the mis-registration detector is to map the regions

in the enhancement frames which are not accurately enough aligned with the reference, and selectively exclude them from the fusion." APPL-1024, 6:44-47.

2. Reasons to combine Parulski, Konno, Szeliski, and Segall.

A POSITA would have combined Parulski and Segall because Parulski teaches image processing, including registration and fusion, and Segall teaches an improvement of Parulski by showing how to handle registration errors during the fusion process. APPL-1003, ¶67. Combining Parulski and Segall would have simply required adding software functionality of Segall's error handing process to Parulski's image processing. *Id.* Thus, combining Parulski and Segall would have been as simple as using Segall's known registration and fusion methods, including error handling, to improve Parulski's registration and fusion processes in the same way. *Id.*

Specifically, a POSITA looking to find a fusion method suitable for Parulski would have recognized that both Parulski and Segall teach similar methods for both registering and then fusing two images together based on pixel correlation (i.e., registration). APPL-1003, ¶68; APPL-1005, 22:14-23:3, 28:45-57; APPL-1024, 3:9-28. Segall expands on Parulski by showing specific methods for fusing together pixels of two images based on registration, the exact issue that a POSITA would look to Segall for implementing Parulski's fusion process. APPL-1003, ¶68; *see* APPL-1024, 3:9-28; 6:44-47. It would have therefore been obvious to combine Segall's fusion process with Parulski because Parulski teaches both pixel correlation and fusion but

does not disclose any specific fusion method. APPL-1003, ¶68. Because Parulski does not disclose a fusion method, a POSITA would have been motivated to seek similar teachings to implement this functionality and would have implemented a process similar to Segall's since Segall and Parulski both base their fusion techniques on first performing image registration. *Id.*

Moreover, POSITAs would have combined Segall with Parulski because processes similar to Segall's for handling errors in a registration map were already known and used by POSITA's for handling registration errors during image fusion. *Id.*, ¶69; *see* APPL-1025, 23:30-41. For example, Dagher teaches an image fusion process that looks to an error map generated at image registration for determining "whether or not to 'color' a certain wavelet block." APPL-1025, 23:42-56. According to Dagher, its algorithm is "particularly useful in the presence of occluded regions, where there are objects visible in the grayscale image data that are not visible in the color image data due to parallax effects, which results in that object having no corresponding color information." APPL-1025, 23:48-52.

Accordingly, a POSITA looking to implement a fusion process compatible with Parulski's image processing method would have looked to methods similar to Segall and Dagher because both teach using image registration to perform image fusion but also include steps for handling registration errors. APPL-1003, ¶70. A POSITA would have expected to succeed in implementing Segall's teachings in

Parulski's cell phone since both teach performing image registration and fusion in software. *Id.*

The following analysis describes how the combination of Parulski, Konno, Szeliski, and Segall renders obvious claims 5-9 and 27-31.

3. Claim 5

[5.0] "The dual-aperture digital camera of claim 4, wherein the camera controller is further configured to process the re-sampled Telephoto image and the Wide image to detect an error in the registration and to provide a decision output."

The combination of Parulski and Segall renders [5.0] obvious because Parulski teaches an image enhancement process that combines a down-sampled Telephoto image with a Wide image and Segall teaches an image registration and fusion process that detects registration errors. APPL-1003, p.80.

As shown in the analysis above, Parulski teaches a dual-aperture camera with Wide and Telephoto lenses that processes images for stereo matching and image enhancement (*see* [1.0]-[1.5.2]). One possible enhancement includes combining portions of the Telephoto image with the Wide image (*see* [1.5.1]). *Id.* This process includes down-sampling the Telephoto image based on a registration map (*see* [4.0]) and combining the down-sampled Telephoto portions with the Wide image to broaden the depth of field in the output image. *Id.* Parulski, however, does not specifically describe how the pixels of the two images are combined. *Id.*, p.80-81. Thus, a POSITA looking to implement this feature would

have selected one of many existing fusion methods like that taught in Segall (APPL-1024). *Id.*

Segall similarly teaches a process for registering and fusing portions of two images. *See* APPL-1024, 3:9-16 ("These systems and methods typically comprise two basic phases: registration and fusion."). The fusion step includes error detection that excludes from fusion areas containing registration errors. APPL-1024, 3:23-28 ("The fusion … **may comprise a mismatch detector which may restrict or exclude areas containing local motion and other registration errors from the fusion process**."); APPL-1024, 6:43-47 ("The goal of the mis-registration detector is to map the regions in the enhancement frames which are not accurately enough aligned with the reference, and **selectively exclude them from the fusion**."). A POSITA would have understood that excluding an area of the enhancement from fusion due to a registration error is "detect[ing] an error in the registration and provid[ing] a decision output." APPL-1003, p.81.

As discussed above, a POSITA would have found it obvious to implement a fusion technique like Segall's in Parulski's image processing method. *Id.*, p.82. Segall's error detection method when applied to Parulski would have similarly excluded areas of the Telephoto image (i.e., enhancement) for any registration errors, thereby providing a decision output based on the registration errors. *Id.*,

p.88. Thus, Parulski's image processing method combined with Segall's method for processing registration errors during fusion renders [5.0] obvious.

4. Claim 6

[6.0] The dual-aperture digital camera of claim 5, wherein, if an error is detected, the camera controller is further configured to choose Wide pixel values to be used in the output image for pixels that caused the error.

The combination of Parulski and Segall renders [6.0] obvious. As discussed above in [5.0], Parulski combined with Segall renders obvious an image registration and fusion process where, based on Segall's teachings, areas of the Telephoto image that correspond to registration errors are excluded from the fusion process. *Id.* Segall describes this process in terms of a mis-registration detector that "map[s] the regions in the enhancement frames which are not accurately enough aligned with the reference, and **selectively exclude them from the fusion**." APPL-1024, 6:43-47.

Since Parulski's fusion process uses the Wide image as the reference image and the Telephoto image for enhancement (*see* [1.5.1]-[1.5.2]), a POSITA applying this error handling technique to Parulski would have likewise excluded portions of the Telephoto image for areas having registration errors. APPL-1003, p.82. This would have left only Wide pixels to be used in the output image. *Id.* A POSITA would have thus understood that the combination of Parulski and Segall renders [6.0] obvious.

5. Claim 7

[7.0] "The dual-aperture digital camera of claim 6, wherein the Wide and Telephoto image sensors have pixels with identical pixel counts and with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ wherein Pixel size$_{Wide}$ is equal to Pixel size$_{Tele}$,"

This limitation is substantially similar to [10.0] and [12.0] and is rendered obvious as discussed above. *Id.*, p.83.

[7.1] "wherein the Wide and Telephoto lenses have different F numbers F#$_{Wide}$ and F#$_{Telephoto}$, and"

This limitation is substantially similar to [14.0] and is rendered obvious as discussed above. *Id.*

[7.2] "wherein the camera controller is further configured to synchronize the Wide and Telephoto image sensors to start exposure at the same time."

This limitation is substantially similar to [16.0] and is rendered obvious as discussed above. *Id.*

6. Claim 8

[8.0] "The dual-aperture digital camera of claim 6, wherein the Wide and Telephoto image sensors have pixels with identical pixel counts and with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ wherein Pixel size$_{Wide}$ is not equal to Pixel size$_{Tele}$,"

This limitation is substantially similar to [10.0] and [13.0] and is rendered obvious as discussed above. *Id.*, p.84.

[8.1] "wherein the Wide and Telephoto lenses have different F numbers F#$_{Wide}$

and F#$_{Telephoto}$, and"

This limitation is the same as [7.1] and is rendered obvious as discussed above. *Id.*

[8.2] "wherein the camera controller is further configured to synchronize the Wide and Telephoto image sensors to start exposure at the same time."

This limitation is the same as [7.2] and is rendered obvious as discussed above. *Id.*

7. Claim 9

[9.0] "The dual-aperture digital camera of claim 6, wherein the Wide and Telephoto image sensors have pixels with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ and wherein Pixel size$_{Wide}$ is not equal to Pixel size$_{Tele}$,"

This limitation is substantially similar to [13.0] and is rendered obvious as discussed above. *Id.*

[9.1] "wherein the Wide and Telephoto lenses have different F numbers F#$_{Wide}$ and F#$_{Telephoto}$, and"

This limitation is the same as [7.1] and is rendered obvious as discussed above. *Id.*

[9.2] "wherein the camera controller is further configured to synchronize the Wide and Telephoto image sensors to start exposure at the same time."

This limitation is the same as [7.2] and is rendered obvious as discussed above. *Id.*

8. Claim 27

[27.0] "The method of claim 26, further comprising processing the re-sampled Telephoto image and the Wide image to detect an error in the registration and to

provide a decision output."

This limitation is substantially similar to [5.0] and is rendered obvious as discussed above. *Id.*, p.85.

9. Claim 28

[28.0] "The method of claim 27, wherein if an error is detected, further comprising choosing Wide pixel values to be used in the output image for those pixels that caused the error."

This limitation is substantially similar to [6.0] and is rendered obvious as discussed above. *Id.*

10. Claim 29

[29.0] "The method of claim 28, wherein the Wide and Telephoto image sensors have pixels with identical pixel counts and with respective pixel sizes Pixel $size_{Wide}$ ***and Pixel*** $size_{Tele}$ ***wherein Pixel*** $size_{Wide}$ ***is equal to Pixel*** $size_{Tele}$ ***and"***

[29.1] "wherein the Wide and Telephoto lenses have different F numbers $F\#_{Wide}$ ***and*** $F\#_{Telephoto}$***,"***

[29.2] "the method further comprising synchronizing the Wide and Telephoto image sensors to start exposure at the same time."

These limitations are substantially similar to [7.0]–[7.2] and are rendered obvious as discussed above. *Id.*, p.86.

11. Claim 30

[30.0] "The method of claim 28, wherein the Wide and Telephoto image sensors have pixels with identical pixel counts and with respective pixel sizes Pixel $size_{Wide}$ ***and Pixel*** $size_{Tele}$ ***wherein Pixel*** $size_{Wide}$ ***is not equal to Pixel*** $size_{Tele}$ ***and"***

[30.1] "wherein the Wide and Telephoto lenses have different F numbers

F#Wide and F#Telephoto,"

[30.2] "the method further comprising synchronizing the Wide and Telephoto image sensors to start exposure at the same time."

These limitations are substantially similar to [8.0]–[8.2] and are rendered obvious as discussed above. *Id.*, pp.86-87.

12. Claim 31

[31.0] "The method of claim 28, wherein the Wide and Telephoto image sensors have pixels with respective pixel sizes Pixel size$_{Wide}$ and Pixel size$_{Tele}$ wherein Pixel size$_{Wide}$ is not equal to Pixel size$_{Tele}$ and"

[31.1] "wherein the Wide and Telephoto lenses have different F numbers F#$_{Wide}$ and F#$_{Telephoto}$,"

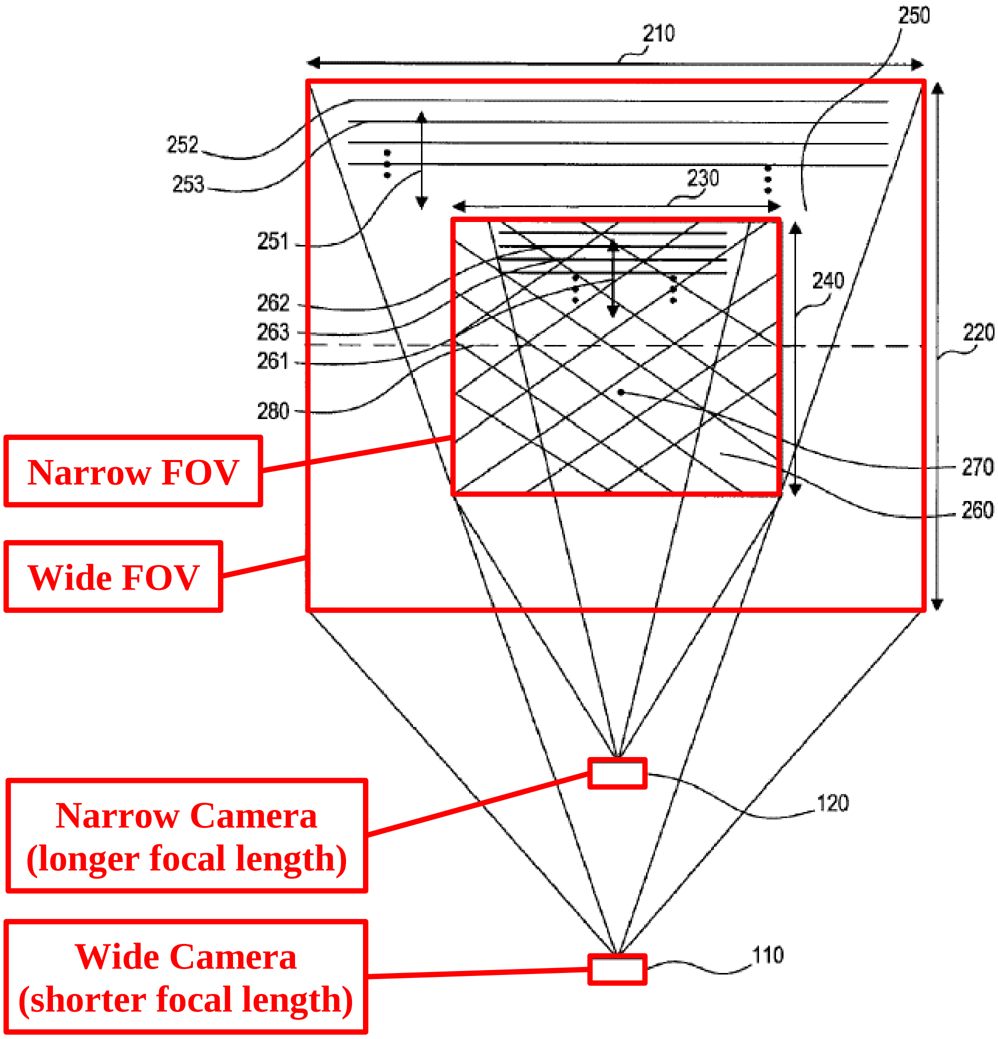
[31.2] "the method further comprising synchronizing the Wide and Telephoto image sensors to start exposure at the same time."

These limitations are substantially similar to [9.0]–[9.2] and are rendered obvious as discussed above. *Id.*, p.87.

D. Ground 4: Claims 15 and 37 are obvious under § 103 over Parulski, Konno, and Stein.

1. Summary of Stein

Stein is directed to a vehicle camera system with "a first image capture device having a first field of view" and "a second image capture device having a second field of view different from the first" that at least partially overlaps. APPL-1023, Abstract; APPL-1021, p.13. An example of the fields of view (FOVs) of Stein's wide and narrow cameras and how they overlap is provided in Fig. 2a:



APPL-1003, ¶72; APPL-1023, Fig. 2a (annotated).

According to Stein, imaging systems with dual cameras used for stereo imaging can use CMOS sensors with rolling shutters. *See* APPL-1023, 5:36-42 ("a CMOS image sensor may be employed along with a rolling shutter"); APPL-1027, p.13. The problem with rolling shutters for stereo image processing is that for cameras having different FOVs "if both cameras acquire images as a similar number of image scan lines acquired at a similar line scan rate, then the acquired

image scan lines in the area of the overlap in the fields of view of the two cameras will lack synchronization." APPL-1023, 2:5-10; APPL-1027, p.13. According to Stein, a lack of synchronization between the overlapping FOVs "may introduce difficulties in determining a correspondence of image points in a first image from the wide FOV camera with image points in a second image from the narrow FOV camera, which can lead to significant inaccuracies object distance measurements." APPL-1023, 2:10-15; APPL-1027, p.13.

To solve this problem, Stein teaches that "by adjusting the image acquisition timing control parameters of each image capture device, however, it may be possible to ensure that the portions of the image frames of each image capture device corresponding to overlap region 270 are acquired during the same period of time." APPL-1023, 10:27-31; *see* APPL-1027, p.13-14. In other words, Stein teaches that for CMOS sensors with rolling shutters, synchronized images (which provide better stereo imaging analysis) can be obtained by setting the timing of each of the rolling shutters such that the portions of the overlapping FOVs on the sensors are scanned at the same time. *Id.*, ¶74. Stein thus provides an improvement to Parulski's cell phone embodiment when implemented with CMOS sensors. *Id.*

2. Stein is entitled to its February 7, 2013 priority date

According to the Federal Circuit, "[a] reference patent is only entitled to claim the benefit of the filing date of its provisional application if the disclosure of

the provisional application provides support for the claims in the reference patent in compliance with § 112, ¶ 1.” *Dynamic Drinkware, LLC v. National Graphics, Inc.*, 800 F. 3d 1375, 1381 (Fed. Cir. 2015). Stein’s claim 1 is entitled to the February 7, 2013 priority date as shown below.

Stein Claim 1	Provisional App. 61/761,724 filed Feb. 7, 2013
[1.0] An imaging system for a vehicle, the system comprising:	*See* APPL-1027, p.13: “The more recent generation of automotive sensors use a rolling shutter which introduces complications for assymetric [sic] stereo. This paper describes the issues and solutions for working with rolling shutter.”
[1.1] a first image capture device having a first field of view and configured to acquire a first image relative to a scene associated with the vehicle, the first image being acquired as a first series of image scan lines captured using a rolling shutter,	*See* APPL-1027, p.13: “The more recent generation of automotive sensors use a rolling shutter which introduces complications for assymetric [sic] stereo. Ideally stereo cameras are synchronized to sub row accuracy in timing. Now consider two cameras such as the Aptina M024 (1280x960 images) one with a 6mm lens and horizontal FOV of 46 degrees and the second with a 12mm lens and horizontal FOV of 23 degrees. The cameras have their optical axis aligned and the central 640x480 part of the wide angle camera matches the full 23 degree FOV of the second camera.”
[1.2] a second image capture device having a second field of view different from the first field of view and that at least partially overlaps the first field of view, the second image capture device being configured to acquire a second image relative to the scene associated with the	*See* APPL-1027, p.13: “However the cameras have a rolling shutter. Assuming the same camera timing in both cameras, the central part of the wide angle camera is scanned in 480 lines while the full 23 degree image takes 960 lines to scan. Thus it is impossible to have all the imager lines synchronized accurately. If the first lines of the original two images are synchronized then only the center line of both images would be both synchronized and spatially aligned.”

Stein Claim 1	Provisional App. 61/761,724 filed Feb. 7, 2013
vehicle, the second image being acquired as a second series of image scan lines captured using a rolling shutter,	
[1.3] wherein, as a result of overlap between the first field of view and the second field of view, a first overlap portion of the first image corresponds with a second overlap portion of the second image; and	*See* APPL-1027, p.13: "Now consider two cameras such as the Aptina M024 (1280x960 images) one with a 6mm lens and horizontal FOV of 46 degrees and the second with a 12mm lens and horizontal FOV of 23 degrees. The cameras have their optical axis aligned and the central 640x480 part of the wide angle camera matches the full 23 degree FOV of the second camera."
[1.4] wherein the first image capture device has a first scan rate associated with acquisition of the first series of image scanlines that is different from a second scan rate associated with acquisition of the second series of image scan lines, such that the first image capture device acquires the first overlap portion of the first image over a period of time during which the second overlap portion of the second image is acquired, wherein the period of time is associated with a ratio	*See* APPL-1027, p.13-14: "One solution would be to run the narrow FOV camera at twice the frame rate of the wide FOV camera and have the first line of the narrow camera synchronized with line 240 of the wide camera. The two cameras will then scan the central region at the same time, the narrow FOV camera outputting two lines for every one line of the wide FOV camera and line sychronization [sic] will be maintained. The second narrow FOV frame which is out of synch can be used or discarded. In practice the narrow FOV camera could simply output the lines in a quick burst and then have a long vertical blanking period." *See* APPL-1027, p.14: "If the line time of the secondary camera can be made faster then one can also reduce the target ratio between focal lengths so that these match the ratio between line timing. For example if the primary sensor has a FOV of 46° and is running at a line timing of 45KHz (22.2usec) but the sensor can support line timing of 60KHz (15.2usec) then a FOV of 32° of the secondary camera can be supported and synchronized precisely:

Stein Claim 1	Provisional App. 61/761,724 filed Feb. 7, 2013
between the first scan rate and the second scan rate.	$\frac{15.2\ \mu sec\ \times 46°}{22.2\ \mu sec} = 31.7°$.

3. Reasons to combine Parulski, Konno, and Stein.

A POSITA would have found it obvious to combine Parulski and Stein because such a combination would have merely been applying Stein's method of setting the rolling shutter timing in stereo CMOS image sensors to the CMOS sensors in Parulski's cell phone camera. *Id.*, ¶76. Applying Stein to Parulski in this way would have yielded the same predictable result of allowing Parulski's dual cameras with different fields of view ("FOVs") to scan the overlapping portions of the respective image sensors at the same time. *Id.*

A POSITA would have looked to Stein to enhance Parulski's image sensors because both Parulski and Stein teach using CMOS image sensors for their respective cameras. *See* APPL-1005, 13:20-25 ("other sensors, **such as CMOS sensors**, … may be used equally well without limitation according to the invention."); APPL-1023, 5:34-42 (the image capture device "may contain any suit able type of image sensor, including CCD sensors or CMOS sensors."), 6:12-17. Parulski and Stein are also both directed to processing stereo images with different fields of view to derive depth data for the scene captured in the images. *See* APPL-1005, 19:49-20:36, Fig. 11; APPL-1023, 2:5-15.

According to Stein, the issue with CMOS sensors in dual-lens cameras with different FOVs (e.g., by having different focal lengths) is that they utilize rolling shutters that "may introduce complications in stereo image processing, especially in asymmetric stereo applications that use cameras having different fields of view." APPL-1023, 1:66-2:1. Stein further explains that "[i]f both cameras acquire images as a similar number of image scan lines acquired at a similar line scan rate, then the acquired image scan lines in the area of the overlap in the fields of view of the two cameras will lack synchronization." APPL-1023, 2:2-5. A lack of synchronization introduces "difficulties in determining a correspondence of image points in a first image from the wide FOV camera with image points in a second image from the narrow FOV camera, which can lead to significant inaccuracies object distance measurements." APPL-1023, 2:5-15.

To solve this problem, Stein teaches a method of setting the rolling shutter timings for each sensor so that the overlapping FOVs between the image sensors is captured at the same time. APPL-1003, ¶78, *See* APPL-1023, 10:27-11:30 ("By adjusting the image acquisition timing control parameters of each image capture device, however, it may be possible to ensure that the portions of the image frames of each image capture device corresponding to overlap region 270 are acquired during the same period of time.").

Since Parulski is similarly concerned with processing stereo images with

different fields of view to derive a range map, a POSITA looking to implement Parulski's cell phone embodiment using CMOS sensors would have, based on Stein, known of the problem that rolling shutters present in stereo image processing of generating unsynchronized images. *Id.*, ¶79. A POSITA therefore would have looked to apply Stein's method of setting rolling shutter timings to synchronize scanning of the overlapping FOVs to the Wide and Telephoto lens systems in Parulski's cell phone camera. *Id.* A POSITA would have recognized that applying Stein's method to Parulski's CMOS sensors would have yielded the same benefit of synchronizing the image capture of the overlapping FOVs in Parulski's camera which would likewise provide more accurate stereo image processing and distance calculations. *Id.* Thus, it would have been obvious to apply Stein's method to control the roller shutter timings to Parulski's CMOS image sensors to overcome the known issues that CMOS sensors with rolling shutters present in stereo image processing. *Id.*

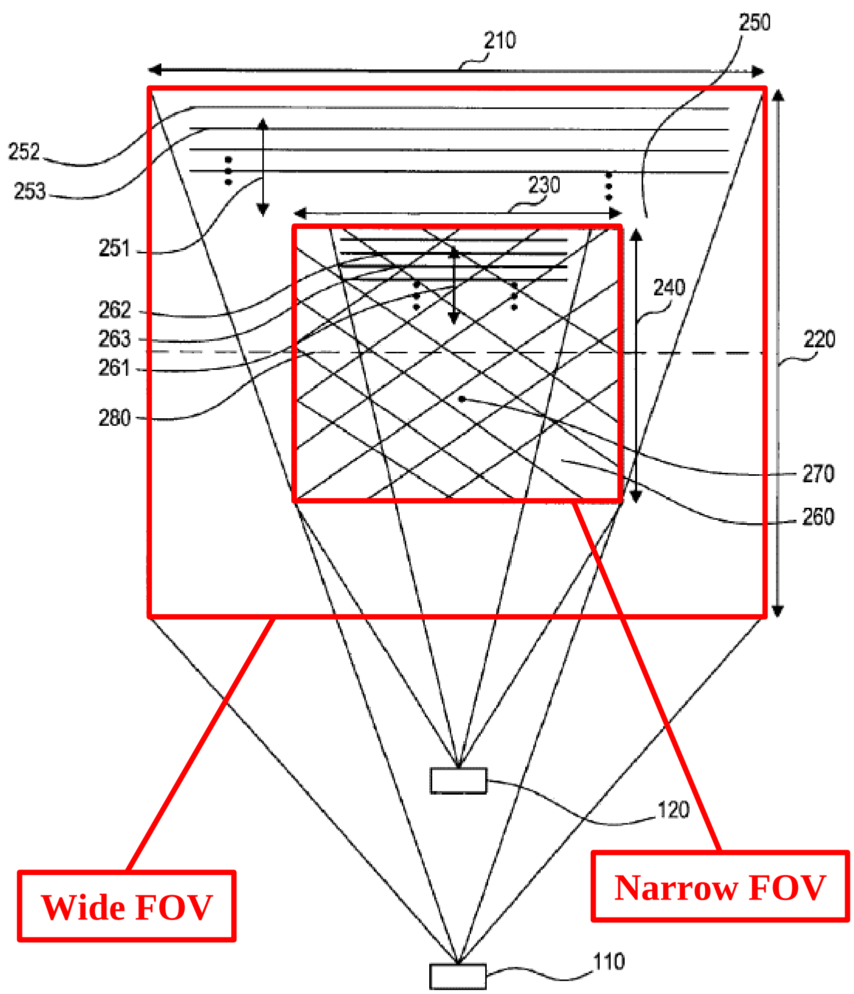
The following analysis describes how the combination of Parulski, Konno, and Stein renders obvious claims 15 and 37.

4. Claim 15

[15.0] "The dual-aperture digital camera of claim 14, wherein the camera controller is further configured to synchronize scanning of the Wide and Telephoto image sensors such that matching FOVs in the Wide and Telephoto images are scanned at the same time."

The combination of Parulski, Konno, and Stein renders [15.0] obvious because Stein teaches synchronizing the scanning of two image sensors so that the

overlapping field of view between the image sensors is scanned at the same time. *Id.*, p.94 Specifically, Stein first teaches using cameras with different focal lengths to capture images with overlapping fields of view (FOVs). APPL-1023, 8:37-43 ("**In some embodiments, system 100 may be configured such that the field of view of image capture device 120, for example, falls within (e.g., is narrower than) and shares a common center with the field of view of image capture device 110.**"); *Id.*, 7:62-67; *see* APPL-1027, p.13. This overlapping field of view is shown in Fig. 2a:



APPL-1003, p.95; APPL-1023, Fig. 2a (annotated).

Second, each of Segall's cameras use rolling shutter times such that the overlapping fields of view are scanned at the same time. APPL-1023, 10:27-31 ("By adjusting the image acquisition timing control parameters of each image capture device, however, it may be possible to ensure that the portions of the image frames of each image capture device corresponding to overlap region 270 are acquired during the same period of time."); *Id.*, 10:41-46 ("Generally, the narrower field of view image capture device 120 should have a scan rate at least high enough such that **the portions of the image frames from both image capture devices 110 and 120 that correspond to overlap region 270 may be acquired during the same time period**."). A POSITA would have understood that images with overlapping FOVs that are captured "during the same time period" is "synchroniz[ing] scanning of the … image sensors such that matching FOVs in the … images are scanned at the same time." *Id.*, p.96.

As discussed above, a POSITA would have found it obvious to combine Parulski and Stein because both references teach using CMOS image sensors for their respective cameras and Stein teaches the benefit of adjusting roller shutter timing to scan overlapping fields of view at the same time. *Id.* Combining Parulski and Stein would have therefore been nothing more than applying Stein's method of adjusting the rolling shutters timings to the CMOS image sensors in Parulski's

camera. *Id.*, pp.96-97. Applying Stein in this way would have yielded the same benefit to Parulski's cell phone camera of providing synchronized stereo images for more accurate stereo image processing. *Id.*

Thus, the combination of Parulski's cell phone implementing Stein's rolling shutter timing method renders [15.0] obvious.

5. Claim 37

[37.0] "The method of claim 36, further comprising synchronizing scanning of the Wide and Telephoto image sensors such that matching FOVs in the Wide and Telephoto images are scanned at the same time."

This limitation is substantially similar to [15.0] and is rendered obvious as discussed above. *Id.*, p.97

X. CONCLUSION

For the reasons set forth above, Petitioner has established a reasonable likelihood that claims 1-16, 18, 23-38, and 40 of the '479 Patent are unpatentable. Petitioner requests institution of *inter partes* review and cancelation of these claims.

Respectfully submitted,

Dated: May 6, 2020

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XI. CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned attorney for Petitioner declares that the argument section of this Petition (Sections I and III–X) has 13,907 words, according to the word count tool in Microsoft Word™.

/Michael S. Parsons/
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CERTIFICATE OF SERVICE

The undersigned certifies that, in accordance with 37 C.F.R. § 42.6(e) and 37 C.F.R. § 42.105, service was made on Patent Owner as detailed below. Patent Owner has authorized electronic service due to the United States Post Office suspending deliver to the address listed in accordance with 37 CFR § 42.105(a). *See* APPL-1036.

Date of service	May 6, 2020
Manner of service	Electronically: mafenster@raklaw.com, bwang@raklaw.com, jtsuei@raklaw.com, nrubin@raklaw.com
Documents served	Petition for *Inter Partes* Review of U.S. Patent No. 10,225,479; Petitioner's Exhibit List; Exhibits 1001–1036
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